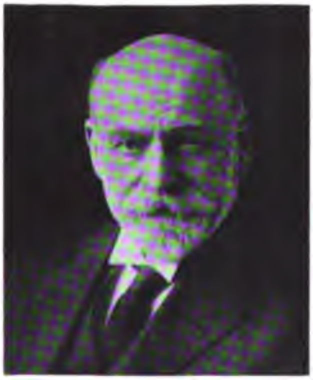

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY
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SOIL SURVEY IN COOPERATION WITH COLLEGE OF AGRICULTURE
H. L. RUSSELL, DEAN

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SOIL SURVEY

OF

WAUSHARA COUNTY

WISCONSIN

BY
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OF THE
WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY,
AND
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OF THE
UNITED STATES DEPARTMENT OF AGRICULTURE

SURVEY CONDUCTED IN COOPERATION WITH THE UNITED STATES
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MILTON WHITNEY, CHIEF.
CURTIS F. MARBUT, IN CHARGE, SOIL SURVEY

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INTRODUCTION.

Before the highest efficiency in agriculture can be attained it is essential that the farmer should have a thorough knowledge of the soil. The degree of success which it is possible to gain on any farm is in direct proportion to the practical knowledge of the soil possessed by the farmer.

The state, working in co-operation with the United States Department of Agriculture, is making a careful study of the soils and agricultural conditions throughout Wisconsin, and is preparing soil maps and reports of all counties in the state. A soil map shows the location and extent of the different kinds or types of soil. All tracts of ten acres and over are mapped and often areas of smaller extent are indicated. Such a map is prepared by trained men who go over a county thoroughly and examine the soil by taking sufficient borings to a depth of 36 inches to keep account of all variations. The report is based upon a careful study of the soils and such other features as have a direct bearing upon the agriculture of the area.

It is the object of this survey to make an inventory of the soils of the state and to be of practical help to the farmers by locating and describing the different soils, by determining their physical character and chemical composition, and by offering suggestions for their management. These recommendations for improvement of the soil types are based upon the soil survey work within the area and upon the results of field tests made by the Experiment Station.

SOIL CLASSIFICATION

Soil fertility depends in part upon the physical characteristics of the soil, such as water holding capacity, workability, etc. It also depends upon the chemical composition, which is determined largely by the source of material composing the soil and its mode of origin.

The water holding capacity and other physical properties of soil all depend chiefly upon *texture,* which refers to the size of individual soil particles. A coarse sandy soil for example will not retain moisture as long as a loam or clay loam, because the finer the soil grains, the greater will be the total surface area to which moisture may adhere and the stronger the capillary movement. The texture of a soil is determined by making a *mechanical analysis,* which is a simple method of separating soil grains into different groups, of which there are seven. These are known as clay, silt, very fine sand, fine sand, medium sand, coarse sand, and fine gravel.

A chemical analysis must also be made to determine the amount of elements essential to plant growth which are present in the soil.

In classifying and mapping soils the soil type is the unit. A *soil type* is a soil which is uniform throughout its entire extent in texture, color, topographic position, and other physical properties, and having a distinct agricultural unity. It is also uniform in the source of material from which derived and the mode of origin which, taken together, determine the chemical composition.

Soil types are grouped according to texture into soil classes, a *soil class* being made up of types having the same texture, though differing in other respects. Thus we have different kinds of clays, clay loams, loams, sandy loams, sands, etc. As shown by the following table, the percentage relationship of the amounts of different sized grains determines the class to which any soil belongs:

CLASSIFICATION OF SOIL MATERIAL

Soils Containing less than 20% Silt and Clay

Soil Classes

Coarse sand—Over 25% fine gravel and coarse sand and less than 50% of any other grade of sand.
Sand—Over 25% fine gravel, coarse and medium sand, and less than 50% fine sand.
Fine sand—Over 50% fine sand or less than 25% fine gravel coarse and medium sand.
Very fine sand—Over 50% very fine sand.

Soils Containing Between 20–50% of Silt and Clay

Sandy loam—Over 25% fine gravel, coarse and medium sand.
Fine Sandy loam. Over 50% fine sand, or less than 25% fine gravel, coarse and medium sand.
Sandy clay—Less than 20% silt.

Soils Containing over 50% of Silt and Clay Together

Loam—Less than 20% clay and less than 50% silt.
Silt loam—Less than 20% clay and over 50% silt.
Clay loam—Between 20 and 30% clay and less than 50% silt.
Silty clay loam—Between 20 and 30% clay and over 30% silt.
Clay—Over 30% clay.

Soil types may also be grouped in another way. Where soils are closely related through source of material, mode of origin, topographic position, etc., so that the different types constitute merely a gradation in texture of otherwise uniform material, such a group is called a *soil series*. It corresponds to the family which is made up of different individuals having the same parentage. The Miami series for example includes light colored glacial material where the soils have been derived largely from the underlying limestone, and the types in this series range in texture from a clay loam to sand and gravel. The Plainfield series includes light colored soils in regions where no limestone

is present and where the material occurs as outwash plains or river terraces. The types in this series have a wide range in texture. The name used for a series usually indicates the locality where that particular series was first recognized and mapped.

By uniting the name of the *soil class* with the name of the *soil series* we get the *soil type.* Therefore when a soil is found to be in the silt loam class, and belongs to the Miami series this constitutes the soil type known as Miami silt loam. Since the soil type is the unit in classifying and mapping soils and the basis upon which experimental work should be conducted, every farmer should be familiar with the types on his farm and their leading characteristics.

SOIL SURVEY OF WAUSHARA COUNTY, WISCONSIN.

CHAPTER I.

GENERAL DESCRIPTION OF AREA.

Waushara County is located a little to the south of the central part of Wisconsin and covers an area of 643 square miles, or 411,520 acres.

The area may be divided into three natural divisions. The western division embraces nearly all of Plainfield, most of Hancock, and the northwestern two-fifths of Coloma townships. This division lies entirely within the Wisconsin River Valley and has a level to very gently undulating topography. It consists mainly of open country, with many narrow belts of Muck soils entering the western boundary and extending from one-half mile to several miles into the county. These belts of Muck usually follow the courses of streams which flow in a westerly direction and drain this part of the county. Very few bowlders occur in this division and the only sandstone outcrop covers a few square rods in section 31 of Hancock Township.

The central division embraces a series of glacial hills crossing the area from north to south and from the Wisconsin River Valley eastward nearly to Bloomfield, Poy Sippi, and Warren townships. It is made up of numerous hills, pothole depressions, and narrow, irregular ridges and valleys. The hills vary in height from 30 to 100 feet or more above the Wisconsin River Valley. This rough rolling topography is most pronounced in the northern part and breaks up into more gentle slopes and more open valleys southward and eastward. The largest of

these valleys, lying almost entirely within Oasis Township, was doubtless at one time a lake with its outlet to the southwest. Several small terraces, their slopes southward, cross the valley from east to west. This valley is nearly all under cultivation. It is locally known as the "Great Prairie".

The smaller valleys of this division opening to the south and east were old drainage channels for the swollen streams of water issuing from the melting glaciers. The streams flowing through these valleys now drain this division. Many beautiful small lakes are scattered through this belt, and areas of Muck are found along most of the streams. Many of the pothole depressions are 100 feet or more in depth, have quite steep slopes, and are usually dry. Most of this division is under cultivation, though considerable areas are still covered with scrubby oak. The soil for the most part is very sandy and numerous granitic glacial bowlders are scattered over its surface.

The eastern division embraces the Lake Poygan and Pine Creek valleys, which are included in Warren and the three eastern townships. The topography of this division is level to gently rolling, and most of the land is under cultivation and highly improved. The drainage is eastward into Lake Poygan.

Fox River, which cuts off the southeastern corner of the county, is the largest stream in the county. It flows in a northeast direction and no streams enter it within the limits of the county. Pine Creek, which drains the northeastern third of the area into Lake Poygan, is the second largest stream. It affords fair water power at different points along its course. Willow Creek, the third stream in importance, drains the central and southeastern parts of the area. Its outlet is in Lake Poygan near that of Pine Creek.

White River and smaller streams tributary to the Fox drain the southern part of the area. Most of these streams have sufficient fall to furnish good water power for manufacturing. The lakes in the morainic belt vary in size from one-half acre to more than a section. Prominent among these are Silver, Pine, and Fish lakes.

Two railroads cross the county from north to south—the Chicago and Northwestern at about the center, with a branch extending to Redgranite, and the Minneapolis, St. Paul, and Sault

Ste. Marie (Wisconsin Central Railway) through the western part of the county. Wautoma, Wild Rose, Glenrock, Springlake, and Lohrville are situated upon the former line, and Coloma, Hancock, and Plainfield upon the latter. These two systems offer good transportation facilities, though the sandy nature of the roads and the many hills make hauling of farm products heavy work. The important markets—Chicago, Milwaukee, Madison, Oshkosh, and Fond du Lac (the first named only 200 miles distant and the others near by)—afford advantageous outlets for the products of the county. Many other small towns are found throughout the county. Good schools are found in every township, and rural free delivery of mail and telephone service extend to all parts of the county.

The area is settled by a mixed population of Germans, Welsh, English, Danes, Norwegians, Poles, and Swedes, most of whom came from the adjoining counties to the south and east; a few, from the Eastern States and from Europe. Nearly all were homeseekers who began to till the land as soon as they settled upon it. The Germans are now the predominant nationality.

SOILS

Waushara County lies almost entirely within the glaciated region, and its soils are the product mainly of ice and water action upon the Potsdam sandstone formation, which underlies the surface soils of most of the county. Several outcrops of granite occur in Marion and Warren townships. This granite underlies the sandstone and sometimes projects through it. The only exposure of the Potsdam sandstone is a very small outcrop in section 31 of Hancock Township.

The soils of the uplands consist of a heterogeneous mass of glacial material in which porphyries and granites are prominent, but which has been derived chiefly from the sandstone formation. Over the hilly and rolling division of the county the soils, which have not been reworked by streams, are members of the Coloma series.

The soils of the Wisconsin River Valley and of the valleys to the east and south were carried down from the uplands and deposited near the close of the ice age when the waters were high

and moving rapidly. These soils have been acted upon by water to a great extent, have been laid down in comparatively uniform layers as river terraces or overwash plains, and are classified as belonging to the Plainfield series.

The heavy soils of the eastern fourth of the county are lacustrine in origin, having been deposited in a lake made by ponded waters against the glacier front. These soils were carried by the water issuing from the glacial deposits and laid down in quiet water. They have been classified as Poygan and Superior soils.

Fourteen types of soil are mapped in the county. The name of each type and its actual and relative extent are given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Coloma sand	156,928	38.1	Waukesha sand	5,504	1.3
Muck	68,480	16.6	Superior loam	3,328	.8
Plainfield sand	58,048	14.1	Coloma stony sand	3,008	.7
Coloma sandy loam	50,944	12.4	Coloma gravelly sand	2,880	.7
Poygan clay loam	23,232	5.6	Coloma loam	2,880	.7
Waukesha sandy loam	17,600	4.3	Superior clay loam	1,152	.3
Poygan clay	9,600	2.3			
Superior sandy loam	7,936	1.9	Total	411,520	

CHAPTER II

GROUP OF SANDY SOILS.*

Coloma Sand

Description. The surface soil of the Coloma sand to an average depth of 8 inches consists of a light brown, loose sand of medium texture. The surface soil contains only a small amount of organic matter, and the water-holding capacity is low. A small amount of gravel may be found scattered over the surface and mixed with the soil in places, but this is never in sufficient amounts to change the value of the type.

The subsoil consists of a brownish-yellow, or yellow loose sand of medium texture which extends to a depth of more than 48 inches. The subsoil frequently becomes coarser below and a small amount of gravel may occur at any depth. Some gravel beds are found within this soil type, frequently within 3 feet of the surface. Rock outcrops occur in a few places, especially along the Red Granite Branch of the Northwestern Railroad. These outcrops occupy from 30 to 60 acres and are extensively quarried.

Coloma sand as found in Waushara County is somewhat variable, and two phases, one heavier and the other lighter than the typical soil, were recognized but not separated on the soil map. The heavy phase is slightly loamy in the surface, and the subsoil is a little heavier than typical. At 30 to 36 inches a sticky sandy loam is frequently found. This phase occurs chiefly in Wautoma and Deerfield Townships and ranks next to the light Coloma sandy loam in producing power. Glacial bowlders are found scattered over the surface of this portion of the type.

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* For methods of improvement and the management of sandy soils see page 25.

The light phase has a lower agricultural value than t typical soil. It contains only a very small amount of orga matter in the first few inches, and throughout its depth it loose and incoherent. The surface material is influenced to greater extent by wind action than the remainder of the typ The light phase is extensively found in Richford, Dakot Springwater, Saxeville, and Leon Townships, and small patch occur through the region of glacial hills.

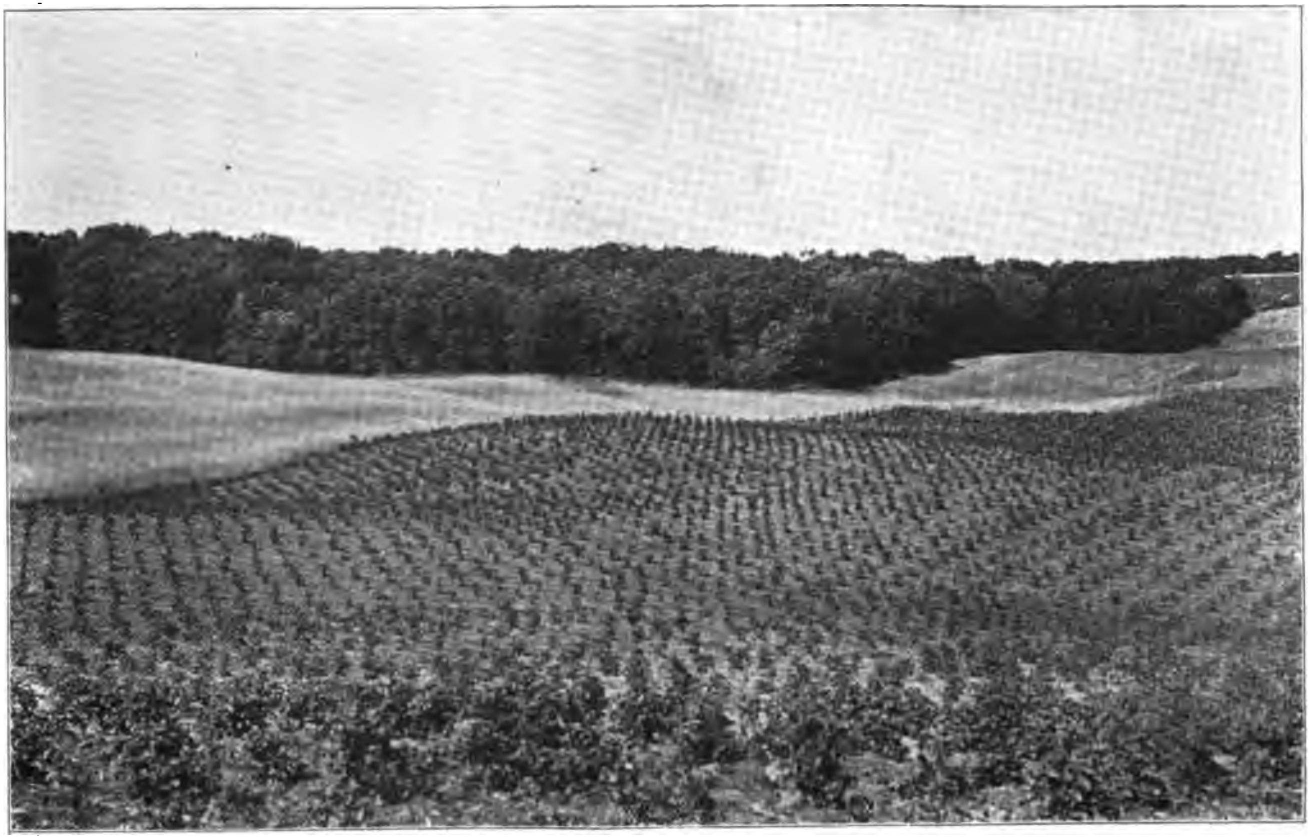
Extent and distribution. Coloma sand is the most extensiv type in the county and occupies 38.1% of the area. It is th predominating soil throughout the central portion of the count and extends from the Soo Line on the west to a line draw through Lohrville, Red Granite, Poy Sippi, and the north-cen tral part of Saxeville Township on the east.

Topography and drainage. The surface of the type as a whole varies from gently rolling to rolling. The light phase occupies gentle slopes to rolling ridges and sometimes rounded hills, while the heavy phase, is on the whole, more rolling. On account of the coarse texture, loose, open structure, and the topography, the natural drainage is often excessive, and crops frequently suffer from drought. The lower the sticky sandy loam subsoil stratum under the heavy phase, the more droughty is this portion of the type.

Origin. Coloma sand consists of glacial material derived chiefly from Potsdam sandstone, which is the underlying formation throughout the greater part of the area. The sand grains consist mainly of rounded quartz particles. The type is deficient in humus and shows acidity when tested with litmus paper.

Native vegetation. The native vegetation consists of oak trees and hazelnut bushes. On the heavy phase the oak is thrifty and tall, but on the light phase it is scrubby and spreading.

Agricultural development. A large percentage of the type is under cultivation. It is easily tilled, and in years of normal rainfall, moderate to good yields are obtained, except on the light phase, which is still largely in a wild state. Some fields of this character have been abandoned, after many attempts to produce satisfactory crops upon them.



VIEW OF COLOMA SAND SOUTHEAST OF HANCOCK, SHOWING CHARACTERISTIC TOPOGRAPHY.
Potatoes and rye are the two crops most extensively grown.

Dairying is followed to a limited extent and does fairly well where there are included in the farm areas of Muck that can be used for hay and pasture. In general farming, potatoes, corn, rye, and hay make up the rotation followed. But little success has been attained in the production of hay, except where especially good methods of soil management have been followed Potatoes yield from 75 to 125 bushels per acre, and in exceptionally favorable years as high as 250 bushels have been obtained on fields of the heavy phase. Corn yields 20 to 35 bushels, rye about 10 bushels, and hay about ½ to 1 ton per acre. Potatoes grown on Coloma sand are of medium size, smooth and mealy. They are generally superior to those grown on the heavier soils or on soils very rich in humus. Sweet corn, beans, and garden peas are crops well suited to this type. From 6 to 10 car loads of beans, mainly grown on Coloma sand, are shipped from Wautoma each year.

The following table gives the average results of mechanical analyses of typical samples of the soil and subsoil of a Coloma sand:

Mechanical analyses of Coloma sand.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent*	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil...	0.4	12.7	18.1	43.2	4.5	6.2	4.9
Subsoil	1.1	13.1	29.7	43.3	4.0	4.9	3.8

COLOMA SANDY LOAM

Description. The surface soil of Colôma sandy loam to an average depth of 8 inches consists of a brown, medium sandy loam, which contains only a moderate amount of organic matter and is usually rather loose and open in structure. The subsoil consists of a yellowish-brown, sticky, sandy loam containing enough stones to make boring difficult. Below 26 inches it is quite common to encounter a mixture of sand and gravel which extends to a depth of 3 to 4 feet. In a few places the subsoil is

a gravelly sand to 36 inches where a sticky sandy clay is reached.

There are a number of variations in the type, though none are of sufficient extent to be separately indicated on the map. In a few localities the surface soil becomes heavier than typical and is a heavy sandy loam. Where the morainic topography is prominently developed the surface is strewn with granitic bowlders, and the soil contains enough stones to interfere somewhat with tillage. Over a few very small areas, very large granitic bowlders were found. Where of sufficient importance such stony tracts were indicated by smybols. On the margin of some of the more rolling areas, and on the brows of some of the knolls, small areas of gravelly sand occur with a thin layer of heavy material near the surface.

Extent and distribution. The Coloma sandy loam is closely associated with the Coloma sand, though it is of much smaller extent, occupying only 12.4 per cent of the county. The largest areas occur in Marion, Springwater, Rose, Deerfield, and Hancock Townships. Other smaller areas are scattered throughout the Coloma sand type. In Marion and Mount Morris townships the surface soil is somewhat lighter, and crop yields are not quite equal to those on the typical soil. As the depth to the heavier subsoil increases, the producing power of the type is decreased.

Topography and drainage. In topography the area of Coloma sandy loam is gently rolling to hilly, with steep slopes and numerous pothole depressions, some of which are 100 feet or more in depth. The type frequently occupies ridges and hilltops, with irregular, narrow intervening valleys of Coloma sand. The potholes were originally small lakes, but with rare exceptions they are now dry. The soil in these depressions is somewhat heavier and contains more humus than that of the type proper, but these bottoms seldom occupy more than a few square rods. They are, however, tilled regularly with the less broken surrounding areas and are frequently used for gardens because of the greater amount of moisture in the soil.

The rolling nature of this type gives it very good, though not excessive drainage. The water table lies at considerable depth

below the surface; but during seasons when the rainfall is well distributed, the type suffers but little from drought.

Origin. The soil is of glacial origin and is composed of a heterogeneous mass of sand, silt, gravel, and clay, with many bowlders, brought from the north and mixed with material derived from the local disintegration of Potsdam sandstone. The sand content of the type consists of rounded particles of quartz and some other rocks. The soil shows a moderate degree of acidity.

Native vegetation. The native vegetation of this type is oak with a heavy underegrowth of hazelnut bushes. From Wautoma eastward scattered hickory is found. The oak is much more thrifty, with longer and more slender trunks, than that found on Coloma sand.

Agricultural development. Where not too stony the soil is easily tilled, and nearly all of it is under cultivation. Potatoes, corn, oats, rye, and hay are the main crops. Potatoes yield from 80 to 150 bushels per acre and under very favorable conditions 300 bushels per acre have been obtained. Corn yields 25 to 40 bushels, oats 30 to 40 bushels, rye 12 to 15 bushels, and hay an average of about 1½ tons per acre. Dairying and potatoes are the two leading specialties on this type. Corn or potatoes, oats or rye, clover, and timothy is the rotation usually practiced. The soil shows a moderate degree of acidity and on account of this some difficulty has been encountered in growing red clover. Fall plowing for rye and spring plowing for all other crops is the usual practice.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Coloma Sandy loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent	*Per cent*	*Per cent.*	*Per cent*	*Per cent*	*Per cent.*	*Per cent.*
Soil..................	0.6	12.8	20.0	33.0	10.6	17.3	5.9
Subsoil............	.6	9.8	18.5	40.2	7.2	10.4	12.8

COLOMA GRAVELLY SAND

Description. The surface soil of this type consists of a loose, coarse to medium, gravelly sand of practically the same texture from the surface to a depth of over three feet. The surface 2 to 3 inches contains a little light brown organic matter, otherwise the surface and subsoil are alike. Gravel occurs upon the surface in most places, though few bowlders are found, the rock fragments varying in size from that of a pea to that of a hen's egg. The gravel and sand deposits extend to a depth of many feet. Frequently strata of medium sand, free from gravel, occur through the material at varying depths, showing the action of water in its deposition.

Extent and distribution. This type is of very limited extent, occupying only 2880 acres. The largest area is found 3½ miles north of Red Granite in the vicinity of Pearl Lake. A small patch occurs 1½ miles northwest of Wild Rose, and another is found 3 miles north of White River Mill Pond.

Topography and drainage. The type has an uneven topography and occurs on narrow ridges and rounded knolls along valleys and old stream courses. On account of the topography, the loose, open structure, and the coarse texture, the natural drainage is excessive, and this type is droughty.

Origin. The Coloma gravelly sand is of glacial origin and was deposited during the melting of the ice sheet. The sand grains consist chiefly of rounded quartz, from the Potsdam sandstone.

Native vegetation. The original timber growth consisted chiefly of scrub oak trees and hazel bushes. Much of the type is still in timber, but this has little value.

Agricultural development. Because of its droughty condition and low fertility only a small part of the Coloma gravelly sand is cultivated. Rye is grown more extensively than any other crop, but the yields are very low and unsatisfactory.

The results of mechanical analysis of a fine-earth sample of the soil are given in the following table:

Mechanical analysis of Coloma gravelly sand.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil................	10.9	47.3	20.5	12.4	5.0	2.4	1.5

COLOMA STONY SAND.

Description. The surface soil of this type to an average depth of 8 inches consists of a brown, medium textured sand, underlain by a light-yellowish sand of the same texture and extending to a depth of 36 inches and over. Both the surface and subsoil contain varying quantities of gravel and stones, which interfere to some extent with cultivation. The surface contains only a very small amount of organic matter, and the type has a low agricultural value.

Extent and distribution. The type comprises an area of about 3,000 acres. It occupies a strip from $\frac{1}{4}$ to 1 mile in width extending across Rose Township from northeast to southeast.

Topography and drainage. The type occupies a roughly rolling position and is morainic in character. Many deep pothole depressions lie between the high ridges and the type as a whole is the roughest in the county. On account of the loose, open structure, coarse texture, and uneven topography, the natural drainage is excessive and the type is droughty.

Origin. The Coloma stony sand is of glacial origin and represents an extension of the rough morainic belt found in Portage County. The material forming the soil came from the grinding of the local sandstone by the ice and the mixing of the fine particles with other rock debris brought from the north.

Native vegetation. The original timber growth consisted of scrub oak with considerable hazel brush. Most of the type is still in timber, but this has little value.

Agricultural development. Where the soil of this type is cultivated, crop yields are low, but compare favorably with those from the Coloma sand. The type has been neglected because of the presence of more easily tilled soils in the same re-

gion. It produces some grass and is used more for pasture than for anything else.

PLAINFIELD SAND.

Description. The surface soil of Plainfield sand to a depth of from 8 to 10 inches consists of a brownish, loose sand of medium texture. The amount of organic matter present in the surface soil is very low. The subsoil to a depth exceeding 36 inches consists of a loose, yellow, porous sand of medium texture. Where the type occurs in the Wisconsin River Valley there is frequently considerable gravel in the subsoil which makes boring difficult in places. In the eastern part of the area little gravel is found in the subsoil.

Extent and distribution. Plainfield sand is the third type in extent of occurrence in the county, occupying 14.1 per cent of the area or about 58,048 acres. The major portion of this soil lies in the western part of the county, immediately west of a line drawn through Plainfield and Hancock. Other areas of considerable size are found in Springwater, Bloomfield, and Mount Morris Townships. Smaller patches occur throughout the easteren part of the county.

Topography and drainage. The type has a level to gently undulating surface in the Wisconsin River valley and is level where found in the valleys of the eastern part of the county. On account of the loose, open character of the soil of this type and its texture, the natural drainage is excessive, and the type is droughty, except where the water table comes nearer the surface than typical, or during years when the rainfall is heavier than usual.

Origin. Soil of this type in the western part of the county occurs in the old Wisconsin River valley and was worked over and deposited at a time when the waters of that stream were flowing at a much higher level than at present. In the eastern part of the county the type probably represents overwash plains, and the material was deposited by streams issuing from beneath the ice sheet. The predominant material is quartz grains from the Potsdam sandstone, though material representing granitic rocks is also present, especially in the subsoil.

FIG. 1. VIEW OF PLAINFIELD SAND IN WESTERN WAUSHARA COUNTY, SHOWING CHARACTERISTIC TOPOGRAPHY.

Potatoes are the leading cash crop on this soil.

WISCONSIN GEOL. AND NAT. HIST. SURVEY. PLATE II.

FIG. 2. VIEW OF PLAINFIELD SAND, SHOWING CHARACTERISTIC TOPOGRAPHY AND FARM BUILDINGS.

Rye is an important crop on this soil.

Litmus tests and the presence of sorrel indicate that the soil is in an acid condition.

Native vegetation. The original timber growth consisted of a scrubby stand of oak on the higher portions; and poplar, birch, and willow, with a few elms, on the lower levels.

Agricultural development. The major portion of the type is under cultivation, and where properly managed fair returns are secured, except during years when the rainfall is not well distributed and long dry spells do considerable damage to growing crops. The chief crops grown and the yields obtained are potatoes from 75 to 125 bushels, corn from 20 to 35 bushels, and hay from ½ to 1 ton per acre. Potatoes are more extensively grown than any other crop and form the cash crop upon which most dependence is placed. The rotation most often followed consists of potatoes or corn, rye, oats, or buckwheat followed by hay. It is difficult to get a stand of clover, and the hay crop is always limited. Dairying is carried on to a limited extent. The type is well suited to truck crops, of which the yield and quality are practically the same as for Coloma sand.

The following table gives average results of mechanical analyses of samples of the soil and subsoil of the Plainfield sand:

Mechanical analysis of Plainfield Sand.

Description.	Fine gravel	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent*	*Per cent.*
Soil................	0.4	11.7	19.6	42.3	12.4	8.4	5.4
Subsoil...........	.7	10.4	21.5	46.0	14.9	3.3	2.9

WAUKESHA SAND

Description. Waukesha sand to a depth of 8 to 10 inches consists of a dark brown to black medium sand containing a small amount of silt and clay and a medium amount of organic matter. Beneath this is found a loose, yellowish-brown sand of medium texture, becoming lighter in color and texture with depth to 36 inches. Below 3 feet the material is a yellowish

gravelly sand. Varying quantities of fine to medium gravel are found at different depths in the subsoil.

Extent and distribution. The type lies west of the morainic belt and is confined to the northwestern portion of Coloma and the southwestern portion of Hancock Townships. It covers an area of about 5,500 acres.

Topography and drainage. The surface of the type is level to gently undulating. Owing to the loose, open characater of the subsoil the water-holding capacity is not high and during seasons when the rainfall is not well distributed the soil suffers from drought.

Native vegetation. The region covered by the Waukesha sand is commonly spoken of a prairie, though over a portion of it there was originally a scrubby growth of oak.

Origin. The type lies within what is frequently spoken of as the Old Wisconsin River Valley and the material composing the soil has been more or less influenced by the action of water. The parent material is largely Potsdam sandstone. The dark color is due to the accumulation of organic matter, the growth of which was favored by moist conditions which prevailed at an earlier time. The soil shows considerable acidity to the litmus test and the type supports quite a growth of sorrel.

Agricultural development. The crops grown upon this type in order of their importance are potatoes, corn, oats, rye, and hay. Potatoes yield from 60 to 125 bushels per acre, corn from 15 to 35 bushels, oats from 15 to 30 bushels, rye from 8 to 10 bushels and hay from one-half to 1 ton per acre. This soil is not suited to hay but early truck crops thrive. The greater proportion of the type is under cultivation. The Waukesha sand has a lower value than the Waukesha sandy loam, but it is a better soil than the Plainfield sand.

The following table gives the results of mechanical analyses of typical samples of soil and subsoil of this type:

Mechanical analyses of Waukesha sand.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*
Soil.............. ...	0.7	31.7	29.5	21.9	3.4	5.6	6.9
Subsoil.............	1.0	23.3	29.3	28.5	3.0	7.9	7.1

CHAPTER III

METHODS OF IMPROVEMENT FOR SANDY SOILS*

There are a number of soils in Waushara County which are so closely related in texture and structure that from the standpoint of improvement and management they may be considered in groups rather than as individual types. All of the sandy types and one sandy loam soil may be grouped together, and this group will include Coloma sand, Coloma stony sand, Coloma gravelly sand, Coloma sandy loam, Plainfield sand, and Waukesha sand.

In chemical composition these markedly sandy soils show less of practically all the important elements than do upland silt loam or clay loam soils. The total phosphorus in the surface 8 inches of this group of sandy soils averages about 800 pounds per acre, while in the silt loam and clay loam soils of the southern part of the state there are approximately 1,050 pounds of this element. The total amount of potassium in the surface 8 inches of the sand soils of Waushara County is, in round numbers, approximately 21,000 pounds per acre, while that in the heavier soils is approximately 45,000. The total amount of organic matter in sandy soils is about one half of that in the light colored silt and clay loam soils of the southern part of the state, and less than one third of that in the upland prairie soils of the southeastern and southwestern parts of the state.

Since Potsdam sandstone is the source of essentially all of these soils, they are very low in lime carbonate, having less than one half of the amount contained in the surface soils of the limestone section of the state; and the subsoils of this group have less than one-tenth of the amount usually found in the subsoils of the southeastern part of the state. It is evident, therefore, that these soils have less of all the essential elements required by plants than is contained in heavier and more fertile soils.

* See Bulletin No. 204, University of Wis., Agr. Exp. Sta., on "Improvement of Sandy Soils".

They have, of course, certain advantages for special crops, and it is possible to profitably supplement their natural supply of plant food material by the use of fertilizers. But all systems of farming on such land should be planned in such a way as either to conserve their natural fertility, or replace it by the use of commercial fertilizers.

The most important differences between these sandy types of soils and heavier classes, such as silt loams and clay loams, however, are not of a chemical nature, but of a physical nature, having to do with their water holding capacity, drainage, tillage, etc.

Suggestions for the improvement of these types are based upon field experiments, chemical and mechanical analyses, and upon studies and observations covering a variety of sandy soils.

In the management of these sandy soils it should be kept in mind that they are naturally low in organic matter and in the mineral elements required, the water holding capacity is poor and the soil is acid. As all of the types in this group, and a large proportion of the soils in the state are in an acid condition and would be greatly benefited by the application of lime, every farmer should know how to test his soil for acidity.* "A very simple and reliable method to detect soil acidity is by the use of blue litmus paper which can be secured of any good druggist. Take a handful of moist soil and form it into a ball. Break the ball into halves and place a piece of blue litmus paper in the center of one of the halves, and cover it with the other half. After 5 minutes break the ball, and if the paper is pink in spots or over the whole end, the soil is acid." "Soil acidity is also usually indicated by the growth of certain weeds, such as sheep sorrel, horse-tail rush, corn spurry and wood horse-tail."

When the amount of organic matter or humus forming material in the soil is increased, the water holding capacity is also increased. The humus forming material can best be increased by applying stable manure and by plowing under legumes as green manure. Of the legumes red and mammoth clover are perhaps better adapted to sandy soils than any of the others, but neither of these nor alfalfa will make the most satisfactory growth until the acid condition is corrected. The mineral elements required may be supplied by the use of commercial fertilizers.

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* See Bulletin No. 230, Wis. Agr. Exp. Sta. on Soil Acidity and Liming.

When a soil can be made to produce a fair crop of clover, without an excessive expenditure, that soil can be successfully and profitably improved. It is therefore important that the first efforts in building up a soil should be directed toward the establishing of conditions which will be favorable for the growth of clover.

From experiments conducted it seems advisable to sow clover without a nurse crop, where the fertility of the soil is very low, since it will then have all of the moisture in the soil for its own growth. There is also some dangers of the young plants being damaged by the hot sun when the nurse crop is removed. The field intended for clover should be plowed in the fall, or as early as possible in the spring, and a top dressing of ground limestone applied at the rate of 2,000 pounds per acre. The field should be harrowed at short intervals to kill all weeds, and this harrowing should be kept up until about the middle of May. Fifteen pounds of seed per acre should be sown and covered to a depth of 1½ to 2 inches. The seeding should be followed by a roller to compact the soil around the seed, and the roller should be followed by a light harrow to roughen and loosen the immediate surface to check evaporation and blowing of sand by the wind. Where it can be secured a top dressing of well rotted manure should be applied before the last harrowing. If manure is not available about 300 pounds of acid phosphate or ground steamed bone-meal and 100 pounds of muriate of potash should be applied at the time of seeding to clover. If only a small amount of manure is available it may be supplemented by ground rock phosphate, and this can be sprinkled over the manure in the spreader and applied at the same time.

Peat may often be used to advantage as a fertilizer if peat marshes are close at hand. It contains a high percentage of nitrogen, but should be supplemented by potash and phosphate fertilizers, as it is deficient in these elements.

Late in summer it may be necessary to clip the weeds which are sure to come. The cutting bar should be run high and the clipping left on the field as a mulch. The second year the first crop should be cut for hay and the second crop plowed under as green manure to prepare the land for a cultivated crop. After the first application, ground limestone should be applied at the rate of about 1,000 pounds per acre once during every rotation.

The amount of commercial fertilizers containing phosphorus and potash which should be subsequently applied will depend on the crops to be grown and especially on the amount of manure produced on the farm.

Alfalfa may be successfully grown on portions of these types of soil, when properly managed. The preparation of the soil and manner and time of seeding is practically the same as for clover, except that the soil should be inoculated with earth from an old alfalfa field or from a patch of sweet clover. About 20 pounds of seed per acre should be sown, and the first year the crop should be treated the same as clover. The second year it may be cut at least three times.

If the clover or alfalfa should fail for any reason, a crop of spring vetch or tare, soybeans, cowpeas, yellow lupine, or serradella may be grown as a green manuring crop and plowed under.

In selecting a rotation of crops to follow on the sandy soils it should be kept in mind that the soil is low in organic matter, and that this must be supplied either by applying manure or by plowing under green manuring crops. When the soil has been built up to a fair stage of fertility, a nurse crop may be used in seeding clover and alfalfa to better advantage than when the soil is very poor; and it is frequently desirable to seed with rye or oats. This system is considered by many to be more desirable, since an extra crop can be secured.

A three, four, or five year rotation may be followed. If but little stock is kept, a three year rotation may be practiced, consisting of one year of a cultivated crop as potatoes or corn, one year rye or oats seeded to clover, and one year clover—the first crop to be cut for hay and the second to be plowed under for green manure. When the fertility of the type is well established, the second crop may be allowed to seed. Good yields have been secured where the soil is well managed. If manure is scarce, acid phosphate and potash may be applied at this time. If more stock is kept the rotation may be extended one year, using the clover field for pasture one season before plowing down the sod. The manure may then be applied to the sod in the winter or early spring of the year the field is pastured. This will increase the growth of clover and benefit the succeeding crop. In a five year rotation alfalfa may be introduced, but this requires that considerable stock be kept, since none of the alfalfa should be sold.

Fig. 3. LIMING ACID SOILS FOR GROWING ALFALFA AND CLOVER IS VERY PROFITABLE.

Both plots from which this hay was cut were inoculated, but only one plot received lime.

Wisconsin Geol. and Nat. Hist Survey. Plate III.

Fig. 4. PEAT MAY BE USED TO ADVANTAGE AS A FERTILIZER ON SANDY SOILS.

Shock of corn on right shows effect of stable manure on sand. Shock in center was from plot which received no treatment. Shock on left shows result of peat when used in conjunction with potash and phosphate fertilizers.

The field should be left in alfalfa for three years with two years given to cultivated crops and grain. Manure should be applied to the cultivated crop and also to the first year of alfalfa. This system is very desirable except that it does not provide any pasture. To overcome this the farm may be divided and both the four and the five year rotation practised. Afalfa may also be grown by itself and kept on the same field year after year, in which case its place in the rotation should be filled by clover. When the alfalfa begins to run out, the field should be reseeded.

In the cultivation of the sandy soils fall plowing for rye, and spring plowing for all other crops, is the usual practice. The seed bed should be prepared to a depth of at least 8 inches and organic matter should be worked in deeply as well as near the surface to increase the water-holding capacity and to induce a deeper development of the roots. When the land is plowed in the spring it is often advisable to pack the soil with a roller, but this should be followed by a light harrow to secure a mulch on the surface. Where the fields are exposed, and the soil is blown by the wind, an effort should be made to prevent damage from this source. The most effective plan is to lay out the land in long narrow fields so as to have crops that cover the ground in the early spring, such as clover and rye, alternate with the cultivated ground.

With the successful growing of clover and possibly alfalfa, the dairy industry may be developed to a much greater extent than at present. By plowing under a crop of clover every few years and by following a definite rotation and approved methods, the yields of potatoes will be greatly increased; and this crop may well be depended upon as one of the chief sources of income for the sandy soils of the area. Beans, peas, sweet corn, etc., could be profitably grown to a much greater extent, and the trucking industry could be extended if proper arrangements were made for marketing. The soil warms up early and is well suited to cucumbers, strawberries, and all quick maturing vegetables.

In the management of this group of soils it will probably be found that Coloma sandy loam and the heavy phase of Coloma sand will respond more quickly to careful treatment than the other types, chiefly on account of their containing a higher percentage of clay in the subsoil.

CHAPTER IV

GROUP OF LOAM AND SANDY LOAM SOILS*

COLOMA LOAM

Description. The surface soil of Coloma loam to an average depth of 10 inches consists of a dark brown friable loam. Beneath this occurs a yellowish-brown loam which becomes somewhat heavier with depth to 18 inches, where the material is a yellowish sticky sandy clay containing some gravel. At 28 inches there is another change, the material at this depth being a yellowish gravelly sand containing some stones and a little clay. The type as a whole contains more organic matter and mineral plant food than either the sand or sandy loam types though about the same degree of acidity exists.

Extent and distribution. The Coloma loam is of very small extent, occupying only about 4½ square miles or 0.7 per cent of the area surveyed. The largest body of Coloma loam extends south from the north central part of Rose Township a short distance into Wautoma Township. A small area is also found in the northwestern part of Springwater Township, occupying an elevated, gently undulating plateau.

Topography and drainage. The topography of the largest area of this soil is slightly, to moderately rolling. While the position of this type gives it good natural drainage, the texture is such that it is capable of retaining sufficient moisture to mature good crops.

Origin. This soil is of glacial origin and is composed of a heterogeneous mass of sand, silt, gravel, and clay brought from

* As the types in this group are not as closely related in texture, origin, color, and crop adaptation as the group of sandy soils previously described, the methods of improvement are discussed for each soil separately, rather than for the group as a whole.

the north and mixed with material derived from the local disintegration of Potsdam sandstone.

Native vegetation. The original timber growth consisted chiefly of oak and a small amount of hickory. Nearly all of the timber has been removed, and the type is practically all under cultivation at the present time.

Agricultural development. This is the best soil of the Coloma series in the county, and is well suited to general farming and dairying. Potatoes yield from 100 to 150 bushels per acre, corn 35 to 60 bushels, rye 15 to 20 bushels, oats 40 to 60 bushels, and hay from 1½ to 2 tons per acre. Dairying is highly developed, and the quantity of manure available is therefore larger for each farm than is the case on the lighter soils. Red clover usually does well though the soil shows some acidity.

Methods of improvement. In chemical composition Coloma loam is markedly different from the more sandy soils described on page 25. The total phosphorus indicated by the analyses of this type so far made is about the same as that given for the sandy soils as described, but the potash content is distinctly larger, as is usually the case in soils of finer texture. The total amount of nitrogen is also distinctly higher, though it must be recognized that where land of this character has been farmed for several years without proper attention to keeping up the supply of fresh and actively decomposing organic matter, improvement in these respects will be required. These soils are for the most part acid. A rotation which gives good results on this type consists of corn or potatoes, oats, barley or rye, followed by clover and timothy. Hay may be cut two years or pastured the second year, before being plowed again for corn. The soil should be given an application of ground limestone at the rate of about 1,500 pounds per acre every four or five years. The stable manure should be carefully saved and applied, and this may well be supplemented occasionally by plowing under a crop of clover or some other legume. Alfalfa should be grown on this type and it will succeed if properly managed. The soil should be limed, fertilized, and inoculated, and the seed may be sown with or without a nurse crop. Dairying should continue to be the leading type of farming on this soil.

The following table gives the results of mechanical analyses of typical samples of the soil and subsoil of the Coloma loam:

Mechanical analyses of Coloma loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent*	*Per cent.*
Soil	0.8	7.8	14 9	19.5	12 1	30.8	14.3
Subsoil	.5	6.6	17.3	24 9	19.2	19.7	11.7

WAUKESHA SANDY LOAM

Description. The surface soil of Waukesha sandy loam to a depth of from 8 to 15 inches consists of a dark brown to black sandy loam of medium texture and is comparatively rich in organic matter. It is underlain to a depth of 24 inches by a brownish-yellow, gravelly, sandy loam, becoming lighter in color to 36 inches. From 36 to 48 inches the subsoil is a yellowish, heavy, gravelly sandy loam. In places the subsoil to 24 inches is a yellowish sandy clay, and this is underlain by a yellowish, sandy, gravelly loam. Along the margin of the area of this soil the surface frequently becomes somewhat lighter in color, owing to the admixture of lighter colored material from surrounding soils. Where the type occurs in the vicinity of Plainfield and west of Coloma the subsoil is frequently lighter than the typical. In these localities the soil is underlain by a yellowish-brown medium sand to 20 inches and then by a sticky sandy clay extending in places to 36 inches or over. In some places the subsoil below 15 inches is a yellowish gravelly sand, containing a considerable quantity of stone fragments from 1 inch to several inches in diameter.

Extent and distribution. Waukesha sandy loam comprises a total area of 17,600 acres or approximately 4.3 per cent of the county. The largest occurrence is in Oasis Township where it is known as the "Great Prairie". Smaller areas are found in Plainfield and Coloma Townships.

Topography and drainage. On the "Great Prairie" the surface is level with occasional slight depressions and a few slightly

elevated terraces. In places where there is a little change in elevation small gravelly, sandy ridges or knolls occur. Over the remainder of the type the surface is level to gently undulating. The natural drainage is good, and where properly cultivated this soil retains moisture very well, except where the subsoil is more sandy than usual.

Origin. The portion of this type in Plainfield and Coloma Townships lies within the old Wisconsin River Valley and has been largely influenced by the action of water. The type as found on the "Great Prairie" has the appearance of being an old glacial lake basin, though it is probable that this region was at one time connected with, and formed a part of, the Wisconsin River Valley, and was cut off from it during glacial time by the dumping of glacial debris in the form of a moraine just east of Plainfield. The material forming the soil is in an acid condition as is indicated by the litmus test and the growth of considerable sorrel.

Native vegetation. The portion of Waukesha sandy loam in Oasis Township never supported a growth of timber. The type near Plainfield supported a scattering growth of oaks, while the small area west of Coloma was a prairie.

Agricultural development. A very large proportion of this type is under cultivation; it is considered a good soil, and most of the farmers living upon it are in a fairly prosperous condition. The type of farming most largely followed consists of dairying in connection with general farming. The chief crops grown and the yields secured are: potatoes 100 to 150 bushels per acre, corn from 40 to 60 bushels, oats from 25 to 40 bushels, rye about 15 bushels, and hay from 1½ to 2 tons per acre. The soil is comparatively easy to cultivate and no difficulty is experienced in securing a good tilth. The soil is adapted to a number of truck crops. Small plots of onions are now grown, and heavy yields of high quality are obtained. Small fruits also do well if given proper care.

Methods of improvement. In chemical composition the Waukesha sandy loam does not vary greatly from that of the sand types discussed on page 25. The chemical analyses, so far made, indicate that the total phosphorus is distinctly lower on the average, which is probably due to the fact that their higher

amount of organic matter, and consequently greater original fertility, has permitted the growth of heavier crops which have removed a larger amount of phosphorus than in the case of more sandy soils. The total quantity of potassium is moderate as is also the total amount of nitrogen. In this connection it must be recognized that a large portion of the nitrogen now found in soils of this class which have been farmed for a number of years is of a resistant character and does not become available to crops readily, so that the use of barn yard manure or green manure treatment is important.

While agriculture is well developed on this type, there are several points which should be kept in mind in the higher improvement of the soil, and one of the most important is that the soil is in an acid condition.* Before the best results can be obtained this should be corrected. About 2,000 pounds of ground limestone should be applied at the first application, and lighter dressings may be given every four or five years thereafter. As a rule clover still does fairly well, as the type is high in organic matter, but this crop will decline as the acidity increases. Potatoes or corn, rye or oats, clover, and timothy make up the rotation most extensively followed. While the soil is high in organic matter, the applications of stable manure may well be supplemented at times by the plowing under of a green crop. The type is deficient in phosphorus, and this may be supplied through ground steamed bone meal. When used to supplement the manure in an ordinary four year rotation, the bone meal should be used at the rate of 200 to 250 pounds per acre once in the rotation.

The following table gives the average results of mechanical analyses of the soil and subsoil of this type:

Mechanical Analyses of Waukesha sandy loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0.3	10.0	22.7	35.4	7.1	12.6	11.9
Subsoil	.7	6.8	15.5	39.8	13.1	11.9	12.2

* See Bulletin No. 230 of Wis. Exp. Sta. on "Soil Acidity and Liming".

SUPERIOR SANDY LOAM

Description. The surface soil of this type to an average depth of 12 inches consists of a grayish to medium brown loamy sand, of medium texture, and containing considerable organic matter. The subsoil consists of a yellowish-red sandy clay, sometimes becoming quite heavy, and grading into a reddish clayey sand. Occasionally a few small rocks and bowlders are scattered upon the surface.

Extent and distribution. Superior sandy loam is a soil of limited extent, occupying only 1.9 per cent of the county, or about 7,936 acres. It is confined to the eastern part of the county, where it is associated with other members of the Superior series and also with the Poygan soils. Most of the type occurs in Bloomfield and Aurora Townships.

Topography and drainage. The surface varies from nearly level to gently rolling, and the natural drainage conditions are good.

Origin. The red clay subsoil, while not as heavy as that of the other Superior types, is also of lacustrine origin. The surface covering of sandy soil, which is in places quite deep, was washed down from the lighter sandy areas near by.

Native vegetation. The original timber growth consisted chiefly of oaks with some hickory. All of the merchantable timber has been removed, and most of the type has been put under cultivation.

Agricultural development. The Superior sandy loam is nearly all under cultivation and where properly tilled holds moisture very well and produces profitable crops. Corn, potatoes, oats, rye, beans, and grasses are grown successfully, and some small fruit is raised. Dairying in connection with general farming is the chief type of agriculture followed. No commercial fertilizers are used, but all of the stable manure obtained is applied to the type.

Method of improvement. In chemical composition the Superior sandy loam is quite different from other sandy loam types. The total amount of phosphorus in the surface soil appears to be rather low, but the other elements occur in larger amounts. Especially is this true of nitrogen and organic matter, which are

found in larger quantity than in the other sandy loam types. This is probably because of the heavier growth of vegetation which this soil has supported as a result of its heavier subsoil. This subsoil is of a glacial nature and usually contains a considerable amount of lime, so that the soil as a whole is only slightly acid; and it is altogether probable that many fields will be found which are not acid at all, and on which clover and alfalfa will do well without the use of lime. It is important, however, that each owner of land of this character make the determination for acidity on his own land because of this variability.

A rotation fairly well adapted to this type consists of corn or potatoes, followed by oats, rye or barley seeded to clover. Hay may be cut two years, and the last cutting of each season saved for seed, though if the field is not very productive, the second crop of the second season should be plowed under. The growing of small fruits including strawberries, and the production of such other crops as peas and beans might well be extended. Where an acid condition exists ground limestone should be applied at the rate of 1,200 to 1,500 pounds per acre.

The following table gives the average results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Superior sandy loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0 0	8.5	17.0	36.0	10.7	12.2	15.7
Subsoil	.0	7.2	12.7	44.3	13.9	9.4	12.1
Lower subsoil	.0	1.8	2.3	13.8	7.5	53.8	20.7

CHAPTER V

GROUP OF CLAY LOAM AND CLAY SOILS*

SUPERIOR LOAM

Description. Superior loam consists of 6 to 8 inches of medium brown heavy sandy loam to loam, underlain by a heavy, tenacious red clay extending to 36 inches or more. On the higher elevations and ridges the heavy red clay comes near the surface and is 20 feet or more in depth. A thin layer of a grayish yellow soil, about 1½ to 2 inches thick, is usually found between the surface soil and subsoil. This layer is similar to the subsoil, but has been acted upon and changed by the organic matter in the soil above. There are scattered over this type occasional small areas, a few square rods in extent, covered with several inches of sand which appears to have drifted from near-by sandy areas or from local deep sandy knolls. A little fine gravel is sometimes found between the surface soil and subsoil. The small quantity of sand in the surface soil prevents it from cracking when dry, except where the soil is very shallow.

Tillage of this type is more difficult than on the Coloma soils because of its heavier texture. The usual depth of plowing is from 4 to 7 inches. Plowing is generally done in the spring, though fall plowing would seem to be best, as it would give the heavy soil an opportunity to weather during winter, would enable it to catch more of the rainfall, and would give the sod a good chance to decay before spring planting. Plowing should be done when the soil is not too wet or puddling will result.

Extent and distribution. This type is of comparatively small extent occupying but a little over 3,000 acres. It is confined to

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* As the Superior loam is more closely related to the clay loam and clay soils of this group than to the loam and sandy loams previously described, it is included with this group.

the eastern third of the county and occurs in irregeular bodies. Most of the Superior loam lies in the townships of Poy Sippi, Leon, and Aurora.

Topography and drainage. This soil occupies gently undulating to moderately rolling areas and is high enough so that most of the type has fairly good drainage. The region of this type lies from 10 to 40 feet above the level of Lake Poygan, occupies low rolling ridges in the Fox River Valley, and forms a belt between the Coloma soils and the Lake Poygan Basin.

Origin. This Superior loam is lacustrine in origin, having been deposited in Green Bay by the inflowing glacial streams when its waters were at a much higher level than at present. It has probably also been influenced, to a limited extent, by ice action. The soil was exposed, later, by the decline of the bay waters. The red color of the subsoil is due to the presence of ferric oxide.

Native vegetation. The original timber growth consisted chiefly of oak, elm, and considerable hickory. The trees are more prolific and longer-lived than those on the sandy types. Practically all of the first class timber has been removed.

Agricultural development. Superior loam is one of the best agricultural soils in the county and is well suited to dairying and hog raising, the main industries of the farmers in this region. Corn, oats, and hay are the chief crops. Corn yields from 50 to 80 bushels, oats from 40 to 60 bushels, and hay about 2 tons per acre. Potatoes are not as well adapted to this as to some of the lighter soils, but clover and timothy do very well. The rotation most commonly followed consists of corn followed by oats, with which timothy and clover are seeded. The land is left in sod from 2 to 5 years, and usually pastured for a couple of years after hay has been cut for two seasons.

Methods of improvement. The chemical composition of Superior loam shows it to have good amounts of most of the essential elements of soil fertility. It is only moderately well supplied with phosphorus, however, and where heavy crops are produced, and especially where grain or hay is sold from the farm and comparatively little concentrated feed stuff purchased, it will be found profitable to use commercial fertilizers containing this element. The total amount of pottasium is large, as is the case with

all members of the Superior series of soils. The total amounts of organic matter and nitrogen are good, on the average. The surface soil is often more or less acid, but the subsoil is well supplied with lime, so that while moderate applications of some form of lime will be necessary on much of this type of soil to permit clover and alfalfa to make their best growth, it is very probable that when alfalfa is well established and drawing on the subsoil, much less lime will be needed than on the more acid sandy soils.

Best results are usually obtained when this type is plowed in the fall, though where drainage is well established, no difficulty is experienced in securing a good seed bed following spring plowing. Where the type is low and inclined to be wet and cold in the spring, tile drains should be installed. Over portions of the type a crop of clover or some other legume should be plowed under occasionally to supplement the stable manure and to assist in keeping up the organic matter and nitrogen content of the soil. About once during each rotation a moderate application of ground rock phosphate could be made to advantage. A rotation quite commonly practiced consists of corn, followed by a small grain crop, usually oats or barley, with which clover and timothy are seeded. Hay is cut for two years before the field is again plowed for corn.

Mechanical analyses of Superior Loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent	*Per cent.*	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil.................	1.2	10.3	23.2	24.7	4.4	17.6	18.6
Subsoil.............	.4	3.0	5.3	9.5	8.4	38.9	34.4

SUPERIOR CLAY LOAM

Description. Superior clay loam, to a depth of 6 inches, consists of a light chocolate-brown to red heavy clay loam of close texture and containing a moderate quantity of organic matter. This is underlain by a pinkish-red, compact, heavy, tenacious clay, containing very little grit, which extends to 24 inches, or

perhaps to 30 inches, below the surface, where it rests upon a reddish incoherent sand sometimes containing pockets of white sand. The red coloring of the sand is apparently due to iron salts leached in from the surface soil.

Extent and distribution. Soil of this type is of smallest extent in the county, occupying only about .3 per cent. of the area, or approximately 1152 acres. This soil is found chiefly in the southeastern part of Poy Sippi Township where it occurs in two small tracts.

Topography and drainage. The type is found in the low flat valley surrounding Lake Poygan, where it occupies slightly higher elevations than the Poygan clay which surrounds it. It is somewhat better drained than the Poygan clay, but needs ditching for the best results.

Origin. The Superior clay loam is of lacustrine origin and was deposited in the same manner as the Superior loam type. There are a number of artesian wells of excellent water on this type. The wells vary in depth from 35 to 150 feet.

Native vegetation. The original timber growth consisted of elm, hickory, and oaks; but all of the best timber has been removed, and most of the type is under cultivation.

Agricultural development. Agriculture is well developed on the Superior clay loam, and dairying and hog raising in connection with general farming is the chief system followed at present. In dry years very good crops are secured, but during wet seasons considerable damage may be done to crops by an excess of moisture. The crops grown and the yields secured are practically the same as for the loam type, and the same system of farming is followed.

Method of improvement. Chemical analysis of Superior clay loam shows it to have good amounts of most of the essential elements of soil fertility. It is, however, only moderately well supplied with phosphorus; and where heavy crops are produced, and especially where grain or hay is sold from the farm and comparatively little concentrated feed stuff purchased, it will be found profitable to use commercial fertilizers containing this element. The total amount of potassium is large, as is the case with all members of the Superior series of soils. The total amounts of organic matter and nitrogen are good on the average. The

surface soil is often more or less acid, but the subsoil is well supplied with lime, so that while moderate applications of some form of lime may be necessary on much of this type of soil to permit clover and alfalfa to make their best growth, it is very probable that when alfalfa is well established and drawing on the subsoil, much less lime will be needed than on the more acid sandy soils.

Because of its heavy texture and close structure, this soil requires careful management and should be cultivated only when the moisture conditions are the most favorable. It is advisable to plow the land in the fall. Practically all of the Superior clay loam would be greatly improved by tile drains and these should be installed. The plowing under of a crop of clover occasionally, to supplement the stable manure, would increase the organic matter and supply of nitrogen, and it would also loosen the soil and make it more loamy. A moderate amount of ground rock phosphate might well be applied once during each rotation. A rotation commonly followed on this soil is one year of small grain consisting of oats, wheat or barley, seeded to clover and timothy. Hay may be cut two years and the field pastured a year before being plowed for corn.

Mechanical analyses of Superior clay loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Soil	0.0	2.5	8.6	25.4	1.9	36.8	24.4
Subsoil	.0	1.1	5.3	16.1	2.6	25.7	49.2
Lower subsoil	.0	1.2	16.2	68.6	2.3	.7	11 2

POYGAN CLAY LOAM

Description. The surface soil of the Poygan clay loam to an average depth of 10 inches consists of a dark brown to black medium textured clay loam containing a high percentage of organic matter. The subsoil consists of a heavy, tenacious, compact, pinkish-red clay which is similar to the subsoil of the Superior clay loam.

Extent and distribution. Poygan clay loam occupies about 5.6 per cent of the county and comprises a total area of approximately 23,232 acres. It is confined to the eastern half of the county, and with one exception to the two eastern tiers of townships. The largest tract is found in Bloomfield and Saxeville Townships and smaller patches occur in Poy Sippi and Aurora Townships. The type is associated with the Poygan clay and with the soils of the Superior series.

Topography and drainage. This type bears the same physiographic relation to the Superior loam as the Poygan clay bears to the Superior clay loam. The Poygan clay loam surrounds the Superior loam and usually extends down to areas of Muck. It occupies low, gently undulating or gently rolling areas and depressions. Over the more rolling portions the natural drainage is good, but in the low-lying places artificial drainage is often necessary.

Origin. The Material composing this type is largely of lacustrine origin. The dark color is due to a large accumulation of organic matter, the growth of which was favored by moist conditions which prevailed over the type.

Native vegetation. The original timber growth consisted chiefly of elm, hickory some oak and poplar, though most of the timber of value has been cut off.

Agricultural development. The greater proportion of Poygan clay loam is cultivated, and the type has a high agricultural value. Corn, oats, grass, and sometimes potatoes, form the rotation most commonly practiced. Corn yields from 40 to 80 bushels, oats 40 to 50 bushels, potatoes 75 to 150 bushels and hay 1½ to 2 tons per acre. General farming in conjunction with dairying and the raising of hogs is the leading type of farming followed, and the soil is well adapted to such a system of agriculture. Red clover and timothy thrive, and where the soil is well drained and not in an acid condition, alfalfa would doubtless grow successfully.

Mechanical analyses of Poygan clay loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0.7	3.9	5.7	11.3	8.3	45.5	24.2
Subsoil	.5	1.4	2.3	9.2	12.4	44.7	29.6

POYGAN CLAY

Description. Poygan clay consists of 8 to 10 inches of dark-brown to black heavy clay, underlain, to a depth of 30 inches, by mottled drab, red, and white clay. From 30 to 36 inches the subsoil is a drab incoherent sand, usually saturated with water. When wet, the surface soil is plastic and very sticky, and when dry, it checks and cracks quite badly. The presence of a great deal or organic matter considerably improves the texture for cultivation, but great care should be exercised in choosing the time for plowing as its physical condition is easily impaired if the soil is worked while wet.

Extent and distribution. This type is of small extent occupying only about 2.5 per cent of the area or approximately 9,600 arcres. It is confined to the eastern part of the county in Lake Poygan Valley. The largest area extends west from Tustin. Smaller tracts occur scattered through the eastern end of the survey. The type is associated with Poygan clay loam and the soils of the Superior series.

Topography and drainage. The soil of the Poygan clay type is low-lying, and the surface is level to undulating. The water-table is only 3 to 4 feet below the surface, and this, together with the low-lying position and the heavy texture, causes crops to suffer considerably from excess of moisture in years of normal to high rainfall. Crops consequently do best during dry years. All of the type is in need of tile drains.

Origin. The type is of lacustrine origin and owes its dark color to the decaying of vegetable matter, the growth of which was favored by the moist conditions prevailing over the type.

Native vegetation. The original timber growth consisted chiefly of elm, oak, poplar, and birch. Practically all of the good timber has been removed. When not tilled for several years, the soil becomes covered with a heavy growth of native grasses.

Agricultural development. Most of this type is under cultivation, and it is a strong soil. Dairying is the most important industry, and corn, oats, and hay are the leading crops grown. Corn yields from 40 to 60 bushels, oats from 40 to 60 bushels, and hay about 2 tons per acre. No systematic order of cropping is followed, and the land when used for hay is often left in grass for several years.

Mechanical analyses of Poygan clay.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand	Very fine sand.	Silt.	Clay.
	Per cent	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent*	*Per cent.*
Soil..................	0.3	2.2	5.5	9.2	3.1	33.4	46.2
Subsoil....	.0	.9	2.0	11.2	10.5	30.5	44.7

METHODS OF IMPROVEMENT FOR POYGAN CLAY LOAM AND POYGAN CLAY

The Poygan soils are essentially the same as the Superior soils, with the difference of a considerable amount of organic matter accumulated through the growth of vegetation, the decomposition and loss of which has been, to a considerable extent, prevented by the wetness of the soil. The total amount of phosphorus is comparatively low, but the other elements, potassium, nitrogen, and organic matter occur in large amounts. In fact, so far as fertility is concerned, phosphorus is probably the only element which will require much serious attention. The surface soils are frequently quite acid, but this will not reduce their fertility on account of the fact that there is a good supply of organic matter; and except where clover or alfalfa are to be grown, the use of lime will not be necessary, as a rule. Much of this land is not at present sufficiently drained, and it is too heavy in texture to permit the most satisfactory growth of alfalfa.

Where an effort is to be made, however, to grow this crop, determinations of acidity should be made and lime applied if an acid condition is found. The subsoil of both of these types is well supplied with lime carbonate, and except for a moderate application in starting alfalfa, liming will not be necessary. The Poygan soils have a high organic content and are not in need of green manuring crops to supply nitrogen. Such crops, however, if turned under would loosen the soil and thus assist in establishing better tilth.

It is important that these types should be carefully handled and the mechanical condition so maintained as to permit the circulation of air through the surface material. Cultivation should take place only when the moisture conditions are favorable, for, if plowed when too wet, the soil may become puddled, and the field remain in poor condition for several years. The soil should be plowed in the fall whenever this is possible. All of the stable manure made should be applied to the fields, and in addition, from 500 to 600 pounds of rock phosphate per acre might well be applied. Subsequent applications of half this amount, once during each rotation will give good results.

All poorly drained places should be drained, and the major portion of these types would be greatly benefited by tiling*.

A rotation of crops well suited to these soils is one year of small grain consisting of oats, barley, or wheat seeded to clover with a little timothy mixed in. The second year the clover from the first crop may be saved for hay, and the second allowed to go to seed. The third year clover and timothy hay may be cut; and the fourth, the field may be pastured. Following this the sod should be plowed for corn. Pasturing may be omitted if there is other grazing land on the farm. This makes a four or five year rotation. Stable manure should be applied to the sod before plowing for corn, or it may be scattered upon the plowed surface during the winter. Lime may be applied by putting some straw in the manure spreader and placing the ground limestone upon this. Rock phosphate may be mixed with the manure, or it may be scattered on top of the loaded manure spreader and applied with the manure.

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* See Bulletin 229 of the Wis. Agr. Exp. Sta. on "The Right Drain for the Right Place."

CHAPTER VI.

MUCK

Description and origin. Occupying numerous low-lying irregular areas and narrow belts along stream courses throughout the county are accumulations of organic matter in various stages of decomposition locally called "Marsh land". The material of such areas varies in depth from 10 inches to 10 feet or more, being shallower near the margins of the areas, and shades in color from a brown in the peaty areas, to a black in the areas of Muck. The underlying material varies from sand to a sticky clay. The proportion of mineral matter is higher along the contact of the Muck areas with the higher lying soils. Decaying organic material with considerable mineral matter incorporated is called Muck. Where there is no mineral matter present, or only a small amount, such areas are in reality Peat, and the areas where water constantly stands at or above the surface, and where grass and other water-loving plants are found, but the ground is too soft to bear the weight of animals, are Swamp. It was not thought advisable, however, to attempt separation of the several variations in the conditions in which these organic soils exist. The Swamp area is small and is distinguished on the map by symbols. These areas were once lakes or channels for the water of melting glaciers. When the water receded, shallow lakes were formed in the depressions; and fibrous plants and water-loving grasses soon filled the depressions with their roots and their decaying tissues. The first stage in this process gives Swamp, the second Peat, and the third Muck.

Extent and distribution. Muck is the second type in extent in the county, occupying 16.6 per cent of the survey, or approximately 68,480 acres.

Most of these areas occur in the western, southern, and eastern parts of the county, the most extensive bodies being found in the eastern fourth of the county where the greater portion of the marshes are true Peat. In the western part these areas occur as narrow fingerlike belts, extending from one-half mile to several miles into Waushara County from Adams County. In the western and southern parts, the material is largely Muck and is underlain with a drab-colored, incoherent sand, usually saturated with water, while in the eastern part it is underlain by a heavy drab to bluish gray sticky clay. The only swampy areas are found in a narrow belt along Lake Poygan.

Topography and drainage. The Muck occupies low lying areas, and the surface is flat, except in a few places around the border of the marshes, where there is sometimes a gentle slope. This, however, is slight in grade, but is of consequence when the marsh is to be drained. The water table over the low lands is from 1 to 3 feet from the surface, and the natural drainage is very poor. None of the marshes are of value for cultivated crops until drainage systems have been installed. In dry periods, when the water table is lower than usual and the surface becomes dry, fires frequently burn over large areas, leaving the underlying sand and rough projections exposed. This usually leaves the land unfit for anything but grazing, though sometimes small areas of the underlying soil are cleared and tilled with good results.

Native vegetation. The native vegetation consists mainly of tamarack, poplar, birch, willow, and a heavy growth of coarse wild grasses.

Agricultural development. The cranberry industry has been followed with success for many years on the Muck areas in the southeastern part of the county, but there is only a small portion of this land devoted to the industry as yet. With good care a bog will continue to bear profitable crops for many years. At present this land is used almost exclusively for the growing of wild grasses for hay and pasture. The yield of hay is from 1 to 1½ tons per acre, and is usually of poor to medium quality. The land sells at from $10 to $40 per acre, depending on the drainage conditions.

*Method of improvement**. The drainage of marshes is the first step toward their improvement. On large marshes the organization of drainage districts and the cooperation of a number of adjoining land owners is necessary, but many farms include areas of this class of land which can be readily drained without legal dfficulties. Proper cultivation of Muck when drained is of the utmost importance. The use of a heavy roller to pack the surface is often advisable since it produces a firmer seed bed which is better adapted to cultivated crops, especially the small grains.

The fertilization of the Muck as found in this area is important on account of the unbalanced condition of the elements contained. The content of nitrogen is high, but the amounts of potash and available phosphorus are low. Stable manure should be kept for the upland soils of the farm, and potash and phosphorus supplied by commercial fertilizers. The first application of rock phosphate should be from 800 to 1000 pounds per acre followed every 3 to 4 years by application of from 400 to 600 pounds per acre. Potash may be applied as the sulphate at the rate of 100 to 150 pounds per acre for such crops as corn, potatoes, cereals, and hay. This fertilizer is quite soluble, and frequent applications are necessary.

When properly drained and fertilized this Muck will produce good crops of corn, potatoes, cabbage, buckwheat, timothy, and alsike clover. When firmed by rolling, small grains can be grown successfully. With proper care good tame grass pastures can be developed on the Muck.

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* See Bulletin No. 205—The University of Wisconsin, Agr. Exp. Sta. on "The Development of Marsh Soils", and Bulletin No. 229 on "The Right Drain For the Right Place."

CHAPTER VII

GENERAL AGRICULTURE OF WAUSHARA COUNTY.

A few settlers entered the county as early as 1848, but little or no attempt was made to cultivate the land until 1850. There were no mineral resources in the county and only a few small areas of timber, so the early settlers were forced to depend on agriculture for their living. Wheat, corn, potatoes, and buckwheat were the first crops grown, and excellent yields were obtained for several years, but wheat soon began to decline in yields, and its production was abandoned. It was found that the sandy soils were well suited to corn, rye, and potatoes, and the growing of these and red clover was extended.

Little attention was given to crop rotation in early times, and it became evident, with the decline in yields, that some changes in the general practice were necessary if the productiveness of the soils was to be maintained. As early as 1875 the settlers began to experiment with a number of new crops to see which were best adapted to the soils and climate. It was soon found that potato culture was well suited to this area and that industry, with dairying, began to receive considerable attention. These two industries, with the production of red clover seed, hog raising, and the growing of beans, corn, rye, oats, and hay constitute the lines of farming now followed in this area. Potato raising and dairying are the two most prominent specialties at the present time, and they have done much to place the county in its present prosperous condition. The cranberry is the chief fruit exported.

In 1910 there were 2,622 farms in Waushara county, the average size of which was 140 acres. Of all of the land in the county 88.6 per cent is in farms, and of such land 61.8

per cent is improved. On the average there are 86 acres of improved land on each farm in the area surveyed. The census of 1910 indicates that 85.2 per cent of the farms are operated by the owners. During the period from 1900 to 1910 the value of farm property in Waushara county increased 82.1 per cent. During the decade of 1890 to 1900 the production of beans and red clover seed was doubled, the production of hay increased 33⅓ per cent and potatoes nearly 300 per cent, though in comparing these figures the possible effect of differences in the seasons must be given consideration. During the past decade the increase in production has not been nearly as great as that indicated above.

Whatever the type of farming, the system of cropping should be arranged so that a good supply of organic matter may be maintained in the soil, because, without this, crop yields are sure to diminish. The rotation generally followed at the present time is potatoes or corn, rye or oats, and clover and timothy. The sandy types are seldom left in sod for more than one or two years, because of the difficulty of maintaining satisfactory stands of grass for longer periods. The loams and clay loams are frequently left in sod from two to five years, the land during the last year or two being used for pasture. In many of the sandy localities where dairying has not been developed, farmers are having difficulty in obtaining sufficient organic matter to maintain the productivity of their soils. Heretofore they have depended upon a clover and timothy sod to plow down, but in recent years they have had considerable difficulty in securing satisfactory growths of red clover, and as a result the fertilizing value of the sod is greatly decreased. One or more legumes in the rotation are vitally important for the maintenance of the fertility of the sands and sandy loams, and where clover fails some other legumes, such as soy beans, cowpeas, or vetch should be substituted until the soils are in condition to support the growth of red clover again. Alfalfa can be grown when the necessary conditions are supplied. Where manure is not available it may be advisable to plow down an occasional crop of legumes, in order to supply organic matter and nitrogen. Care should

be exercised, however, in the plowing down of green crops, and if the growth is very heavy it is a good plan to give the land an application of lime. Commercial fertilizers can also be used to advantage on many of the soils.

Crop yields are greatly influenced by the methods of tillage used, and this is an especially important matter in Waushara county. The general practice is to plow in the spring for all crops except rye, for which the land is prepared early in the fall. Some farmers break sod land early in the spring, while others wait until just before planting time, claiming this is best as the sod prevents the soil from washing. Some systematic tests in tillage for the various types of soil would undoubtedly prove very beneficial. Spring plowing may be the most advisable for the sands and sandy loams, as their open texture permits free circulation of air, which aids in the rapid decomposition of organic matter. However, spring plowing is usually more shallow than fall plowing and the organic matter is kept near the surface. This causes the greatest root development to occur near the surface and in times of drought the crop is more likely to suffer for moisture than if the organic matter were worked deeper into the soil. If deeper spring plowing is practiced on the sandy soils, it may be advisable to firm the soil by using a corrugated roller. On the loams and clay loams, where there is little danger from washing, it would seem best to plow the sod land in the fall, as this method will give the organic matter sufficient time to decay, will destroy many worms and other pests, will have a better effect upon the granulation of the soil, and enable it to catch and hold more of the water which falls. A seed bed at least 10 inches deep is advisable for the heavy types, while on the sandy soils more shallow plowing is usually advisable, except under certain conditions. At present most of the plowing is done with single-share plows. With the easily tilled soils of this region and the scarcity and high price of labor, it would seem better to use gang plows.

With an average annual rainfall of only 28.3 inches and the usual occurrence of a period of dry weather during the growing season, it is very necessary to conserve all the moisture

possible for the growing crops, especially in the case of the loose sandy types of soils. The field may be properly plowed and the seed bed well prepared, and yet crops may fail, unless frequent and careful cultivation be practised during the growing season. In the sandy soils the aim should be to maintain the largest supply of moisture in the zone of greatest root development, which is from 3 to 24 inches below the surface, with the most effective region between 3 and 12 inches below the surface. Deep cultivation should be avoided when the plants have made considerable growth, as it cuts the surface roots and forces the root development below the richest part of the soil; but an effective mulch should be maintained during the growth of all intertilled crops by cultivating frequently cultivated the soil, to a depth of 4 feet, contained weeds and the loss of moisture otherwise drawn off by them. It will also reduce to a minimum evaporation of moisture from the soil itself, and this is by far the most important result of cultivation as affecting moisture conditions. From an examination of various types of soil in this county it was found that in every instance where fields had been well tilled and frequently cultivatedq the soil, to a depth of 4 feet, contained a moderate supply of moisture even during the driest part of the summer, while adjoining fields of the same types of soils, planted to the same crops, which had not received good cultivation, were in a droughty condition and the crops were suffering badly.

Most of the farms are operated by the owners and most of the labor is performed by members of the family. There is a general scarcity of help during potato-digging time, and from $2 to $2.50 a day, with board in addition is paid for good men. Much hand labor is being eliminated by the use of machinery. Many of the potatoes, however, are still dug by hand with forks, though this method is rapidly being displaced by machinery which elevates the potatoes into boxes, one man sorting the potatoes and changing the boxes as the work progresses.

In parts of the county where the soil is very light the tendency is to increase the size of farms, but on the older and better farms, especially those of the heavier types of soil, the

land is being divided into smaller tracts, usually among the members of the family.

SPECIAL INDUSTRIES.

The importance of a number of specialized crops for the soils of Waushara county can not be emphasized too strongly. With one special industry developed to the practical exclusion of other crops there is always the risk of overproduction or failure, whereas by giving attention to several specialized crops the loss of one may not seriously handicap the farmer. Every agricultural community should direct its attention to a few specialized crops suited to the soils and climate and by organization provide a way to dispose of the products in the most direct and profitable manner. The crops discussed in this chapter are very well suited to the soils and climate of the region, some of which are now being more or less extensively grown in this county.

Potatoes. As early as 1875 it was found that the sands and sandy loams of this area were well adapted to the growing of potatoes, and this industry has greatly increased since that time. In 1900 the yield from 23,685 acres was 1,905,737 bushels or an average of about 80½ bushels per acre. This was 17 bushels per acre less than the crop reported in 1890. In 1910 the yield from 21,599 acres was 2,255,887 bushels or about 104 bushels per acre. The increase over the yield reported for 1900 was probably due to more favorable weather condition rather than to any increased fertility of the soil. In fact the observations made in the field indicate that the yields per acre are gradually decreasing, due to a failure to maintain the productivity of the soil, either through lack of care in cultivation, or to the difficulty of securing good stands of clover, with a consequent depletion of humus and nitrogen.

The Rural New Yorker, Burbank, Early Ohio, Triumph, Hebron, and Early Rose are the main varieties of potatoes grown.

In growing this crop on land supporting a heavy sod it is a good plan to plow either in the fall or early in the spring, as this gives the sod a chance to rot well and destroy insect pests. The seed bed should be at least 7 inches deep, so that

the roots can develop downward into the moist soil. Disking and harrowing should begin in early spring and continue until time of planting, in order to conserve all the moisture possible. This practice should also be followed in the case of land plowed in the spring. No definite time for planting can be set, as this process is controlled by weather conditions. Potatoes should be harrowed at least once a week after they are planted until they are large enough to be cultivated. This will keep the weeds down and also keep a good mulch on the surface and prevent loss of moisture. Frequent cultivation should be given this crop—once a week is not too often. Level cultivation, which is generally practiced, is advisable, as it exposes the least surface to evaporation. The first cultivation may be deep, but subsequent cultivations should be shallow, not more than 2 inches of the soil being stirred.

Many potatoes are hauled directly to the station and sold, many are stored in warehouses, and some are pitted in the field to be hauled to market later. A charge of 2 cents per bushel is made for storage in warehouses, and 1 per cent is deducted for shrinkage in weight for each month.

Fruit. While Waushara county is not one of the chief fruit sections of the state, fruit of several kinds can be grown at least for home consumption. Strawberries and native plums do well on most of the light soils of the county, and fair success with the more hardy apples, such as the Duchess, Wealthy, McMahon, Fameuse, and Northwestern Greening, and some varieties of crabs can be expected with reasonable care. The bush fruits can also be grown on most of the soil types in the county and do exceptionally well on the heavier types. Cranberries have been grown on some of the marshes in the vicinity of Berlin for a great many years, and conditions in that section are well adapted to this crop.

Trucking crops. It has been demonstrated that profitable yields of sweet corn, garden peas, and asparagus can be obtained on the sands, sandy loams, and loams. The development of a trucking industry must depend to a considerable degree upon the establishing of local canning factories, but there is apparently nothing to prevent the profitable use of wide areas for the production of these crops whenever enough

interest can be aroused to cause concerted action of a number of farmers in their cultivation.

Sorghum. Considerable sorghum is grown on the lighter soils, the product being used by the local mills to make syrup. The lightest phase of newly broken Coloma sand produces the best quality of syrup. As the soil becomes heavier and the humus content increases, the color of the syrup becomes darker and the quality less desirable. As there are extensive areas of this type of soil in the county this industry might be extended sufficiently at least to supply local demands.

Beans. The Coloma sand, Plainfield sand, Coloma sandy loam, and Superior sandy loam are very well adapted to the production of navy and other kinds of beans. More than 40 varieties have been tested with varying degrees of success. The land should be well prepared and manured preparatory to planting and the crop should be frequently cultivated during its growth to keep the weeds down and conserve soil moisture. It is a splendid crop to use in rotation, matures quickly, and yields good profits.

Dairying. Dairying has developed into a very profitable industry on the sandy loams, loams, and clay loams of the county. It is followed to a limited extent on the sands, where it gives moderately good results, especially if there are Muck areas adjoining the sands to furnish hay and pasturage. The milk is sold to local creameries for buttermaking, and the skim milk is usually returned to the farmer for hog feed. Some attention has been given to special breeds of dairy cows, but many herds are composed mainly of grade animals. Jerseys, Holsteins, and some Guernseys are the leading dairy breeds. Silos are used quite extensively and much of the corn grown is used for ensilage. The raising of hogs and sheep has developed considerably in the eastern part of the area where the soils are heavier and grass crops are grown more easily.

Dairying and hog raising have been very important factors in the present prosperous conditions in the county and their further development, together with the improvement of the breeds of cattle, will have much to do with the future prosperity of Waushara County farms.

CHAPTER VIII.

CLIMATE.*

"Among the factors which influence the agriculture of a state, none is more important than climate. The class of crops which can be grown is largely determined by the length of the growing season, and the amount and distribution of the rainfall". Any one of these factors may determine the type of agriculture which can be practiced to best advantage.

"The distribution of the rainfall over Wisconsin is remarkably uniform, the average yearly percipitation having a range of from 28 to 34 inches,while the mean for the state as a whole is 31 inches. This is a slightly heavier rainfall than is received by eastern England, northern France, most of Germany, Sweden, and the Dundee Valley. As compared with other portions of this country, Wisconsin has a total rainfall equaling that of central Oklahoma and Kansas, northern Iowa, Michigan, northwestern New York, or the Puget Sound Basin of Washington. But owing to its northerly location the lessened evaporation probably makes the precipitation as effective as that of Arkansas, Illinois, or Virginia."

"The local distribution of rainfall varies, however, from year to year, some sections receiving more rainfall one year, and other sections more in other years. The variation is caused by the movement of cyclonic storms." The average rainfall for the entire state during the driest year was 21.4 inches and for the wettest year 37 inches.

"Of equal importance in agriculture, to the total rainfall, is its seasonal distribution, and in this respect Wisconsin is un-

* This chapter has been based largely upon Wisconsin Bulletin 223 on "The Climate of Wisconsin and Its Relation to Agriculture." This bulletin should be consulted for more information on the subject.

usually fortunate, since about half of the total rainfall comes in May, June, July, and August, and nearly 70% from April to September, inclusive. June has the heaviest rainfall, averaging 4.1 inches, while July averages 4 inches and May-3.9 inches. The precipitation during the winter, on the other hand, is slight; December, January, and February each averaging from 1 to 1.5 inches of rain and melted snow. The average rainfall for the state during winter is 3.9 inches, during spring 8.3 inches, during summer 11.4 inches and during autumn 7.4 inches." Most of the rainfall occurs just preceding and during the period of plant growth, thus being received by the crop at the most effective time. "Wisconsin receives during the growing season, April to September inclusive, an average of 21 inches of precipitation, which is as much rain as that received during the same months by eastern Texas, Illinois, Ohio, or eastern New York. The small winter precipitation in Wisconsin, mostly in the form of snow, on the other hand, causes virtually no leaching of fertility from the soil, or erosion."

Another phase of rainfall distribution of great importance is its variation within a period of a few weeks. Frequently periods of drought and periods of unusually heavy rainfall occur, continuing for one to four weeks, but occasionally longer. Observations taken at Madison by the Weather Bureau over a period of 30 years from 1882 to 1911, inclusive, show that there are on the average three ten day periods during each growing season when the amount of rainfall is so slight that crops on a reasonably heavy soil (Miami silt loam) actually suffer from the lack of moisture. In Waushara County where sandy soils greatly predominate this condition would be even more marked than in regions having a heavy soil.

The eastern portion of Waushara County lies within "The Fox and Wolf River Basins" which are recognized as forming one of eight climatic provinces in Wisconsin. This region has an intermediate climate, partaking some of the influence of the lake but exhibiting more of the features of a land cli-

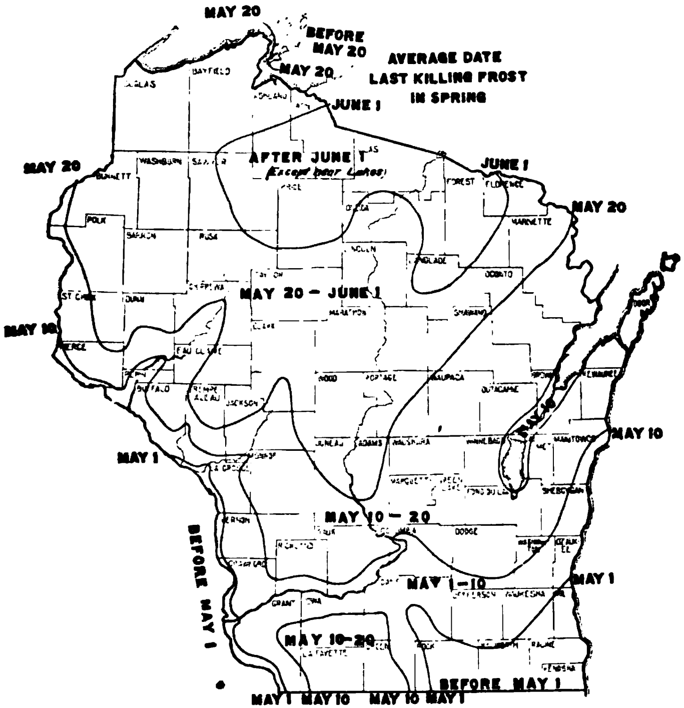

FIGURE 6. LAST KILLING FROST IN SPRING

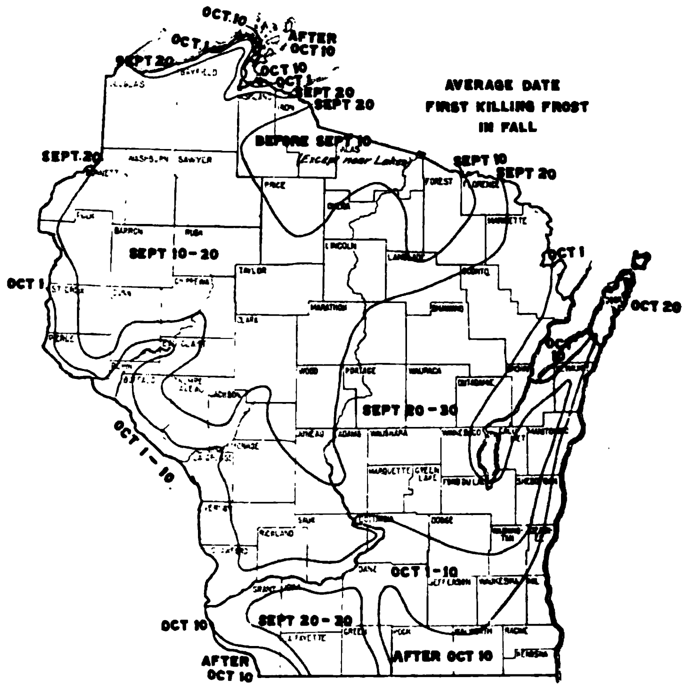

FIGURE 5. FIRST KILLING FROST IN FALL

These maps have been prepared from the original monthly reports of the observers of the U. S. Weather Bureau for the past 12 years, supplemented by private records.

mate. The winters at Green Bay, Appleton, Pine River,* Oshkosh, and Fond du Lac, with a mean temperature averaging 18.7°, are as warm as those at Dodgeville or at Lancaster, while the springs (43°) and the summers (68°) are as cool as the average of Eau Claire and Osceola. The growing season of 130 to 150 days, however, shows the land influence, being of about the same length as Richland, Buffalo, and St. Croix counties, Wisconsin; or Cattaraugus, Chenango, and Deleware counties, New York; Center and Lycoming counties, Pennsylvania; northern Iowa; or central Utah. The rainfall (29.6 inches) in this region is possibly a little less than elsewhere in the state."

By reference to figures 5 and 6, it will be observed that the average date of the last killing frost in the spring in the region including Waushara County is between May 10 and 20. The average date of the first killing frost in the fall in this same region is between September 20 and 30, thus giving a growing season of from 133 to 143 days. From the data given on these two maps, the length of growing season for any portion of the state may be readily determined.

The following table, compiled from the records of the Weather Bureau station at Hancock, shows the mean monthly, seasonal, and annual temperature and precipitation. The data here given are computed from records covering a period of ten years, and while the figures apply in general to the county as a whole, there are doubtless some local variations in rainfall and temperature which the table does not bring out.

* Located in Leon Township, Waushara County.

Normal monthly, seasonal, and annual temperature and precipitation at Hancock.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	°F.	*°F.*	*°F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	20	50	−25	1.2	1.8	1.1	7.5
January	16	53	−30	1.1	1.4	1.6	10.1
February	16	53	−35	1.2	1.2	1.6	7.9
Winter	17			3.5	4.4	4.3	25.5
March	30	73	- 8	1.7	0.5	1.2	6.5
April	46	85	11	2.4	1.0	2.9	2.8
May	58	93	25	3.7	1.8	5.6	.5
Spring	45			7.8	3.3	9.7	9.8
June	67	99	31	4.2	1.4	7.3	.0
July	72	100	44	4.0	1.8	4.0	.0
August	69	100	40	2.9	3.4	4.0	.0
Summer	69			11.1	6.6	15.3	.0
September	61	94	20	2.6	1.4	2.7	.0
October	50	84	15	2.1	0.4	1.0	.5
November	32	68	10	1.2	1.7	1.1	3.9
Fall	48			5.9	3.5	4.8	4.4
Year	45	100	−35	28.3	17.8	34.1	39.7

The climate of this area is invigorating and healthful. Though the winters are long and severe, the temperatures sometimes falling as low as —35° F., the air is usually dry and the cold is not so penetrating as in more humid climates. The soil generally freezes to a depth of 1 to 3 feet and is covered with snow from December 1 until about the 15th of March.

The summers are usually short and very pleasant, the temperature seldom reaching 100° F. The high percentage of sunshiny days causes crops to develop very rapidly, and they

mature in a relatively short time. In average years the growing season at Hancock extends from the middle of May to the latter part of September; from the recorded data of killing frost its length is one hundred and thirty-one days. The average date of the last killing frost in spring at Hancock is May 16 and of the first killing frost in fall September 24.

SUMMARY.

Waushara County is located in the south central part of Wisconsin. It has an area of 643 square miles, or 411,520 acres. It comprises three physiographic divisions, namely, the Wisconsin River Valley, the morainic belt, and the Lake Poygan and Fox River valleys. The valleys have a level to gently rolling topography; the morainic belt is quite broken and hilly.

Wautoma, the county seat, is centrally located. The rural population is well distributed throughout the county.

Fourteen soil types are shown in the map. These soils range from Muck to heavy clay. The heavy soils are used mostly for dairying, hog raising, and the growing of general farm crops. The sandy soils are devoted to potatoes and bean culture and are well suited to sweet corn, garden peas, and other truck crops. The great diversity of soils in the county offers excellent opportunities for the growing of many profitable crops.

The Coloma sand is by far the most extensive type. It is well suited to potatoes, beans, corn, rye, small fruits, and quickly maturing truck crops. This type is usually low in organic matter and responds well to manure.

Coloma sandy loam is found entirely within the morainic belt and is well adapted to general farm crops, alfalfa, fruit, potatoes, and the crops recommended for the Coloma sand.

Coloma loam has a very small extent. It is well suited to general farm crops, dairying, hog raising, and fruit.

Only a small area of the Coloma stony sand is found. Because of its stony nature it is not well suited to farm crops. It is used for pasture. When well tilled it produces moderate yields of corn, rye, potatoes, and beans.

The Coloma gravelly sand occurs as small irregular ridges along stream courses and has a low agricultural value.

Waukesha sandy loam is rich in organic matter and a productive type. Dairying and hog raising are the main industries. Potatoes, corn, rye, oats, and hay are the chief crops. This type is also well suited to the growing of onions and truck crops.

Waukesha sand has about the same producing power as the Coloma sand. If well tilled and manured it will yield moderately good crops. It is a good early truck soil, but needs organic matter and lime.

Plainfield sand occupies the level areas in the western, southern, and eastern parts of the county. It is a light to medium brown sand, low in humus, and inclined to be droughty. When well manured and cultivated, it produces moderately good crops of potatoes, beans, corn, oats, buckwheat, and hay. This type needs lime and organic matter to grow red clover successfully. It is well adapted to small fruits, quickly maturing truck crops, Canada peas, and beans.

Superior loam occupies small areas on ridges and uplands in the eastern part of the area. Dairying and hog raising are highly developed industries. The area of this type of soil is well drained, has good roads, and produces good crops of clover and timothy, corn, and oats, but is usually too heavy for potatoes and truck crops. It is well adapted to apples and small fruits.

Poygan clay loam is a dark-colored soil, rich in organic matter and very productive. Dairying and hog raising and the growing of general farm crops are the main industries on this type.

Poygan clay occupies low-lying level areas in Lake Poygan Valley. Good crops of corn, oats, and hay are produced and dairying is a thriving industry. It is generally in need of drainage.

Superior clay loam is closely associated with Poygan clay, being usually surrounded by the latter type. It lies a little higher than the Poygan clay and produces the same general farm crops. Many good artesian wells are found on this type, as on the preceding type.

Superior sandy loam is a well-drained type and produces good crops of potatoes, corn, oats, rye, and hay. It differs from Coloma sandy loam in having a heavy red clay subsoil.

Muck occurs to a large extent in the county, being usually found in irregular shaped, low-lying bodies and in narrow belts along stream courses. Cranberry growing has developed quite extensively in Aurora township on this type. Very few areas have been drained.

Agriculture is in a prosperous condition. Potatoes, corn, oats, rye, cranberries, and hay are the chief crops, and dairying and hog raising are the two leading industries. The milk is made into butter in local creameries.

Most of the labor is done by the owners of the farms and their families, but some hired help is used during the digging of potatoes and harvesting of other crops.

The summers are short and pleasant and the winters long and cold. The average yearly rainfall for a period of ten years is 28.3 inches. The drainage is to the south and east into Lake Poygan and Fox River.

KEEP THE MAP

The Experiment Station will publish bulletins from time to time dealing with the management of the different types mapped, so that some way should be found by each person receiving a copy of this report to keep the map permanently. If the map is folded in such a way as to have the part you are interested in of a convenient size and then have a simple frame with glass made to hold it, it can be kept indefinitely. Since some of the colors fade after being exposed to strong light for a long time, it would be a good plan to have a protecting flap of dark cloth over the map when not in use.

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

E. A. BIRGE, Director W. O. HOTCHKISS, State Geologist

A. R. WHITSON, In Charge, Division of Soils

SOIL SURVEY IN COOPERATION WITH THE COLLEGE OF AGRICULTURE

H. L. RUSSELL, DEAN

BULLETIN NO. XXIX SOIL SERIES NO. 3

SOIL SURVEY

OF

WAUKESHA COUNTY

WISCONSIN

BY

A. R. WHITSON, W. J. GEIB AND A. H. MEYER

OF THE

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

AND

PERCY O. WOOD AND GROVE B. JONES

OF THE

UNITED STATES DEPARTMENT OF AGRICULTURE,

SURVEY CONDUCTED IN COOPERATION WITH THE UNITED STATES DEPARTMENT OF AGRICULTURE, BUREAU OF SOILS, MILTON WHITNEY, CHIEF. CURTIS F. MARBUT, IN CHARGE, SOIL SURVEY

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SUMMARY

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INTRODUCTION

Before the greatest success in agriculture can be reached, it is necessary that the farmer should have a thorough knowledge of the soil upon his own farm. A soil may be well adapted to one crop, and poorly adapted to another crop. Clover will produce a vigorous growth and profitable yields on the average loam soil which contains lime and is in a sweet condition; but on a sandy soil which is sour, or in an acid condition, clover will not make a satisfactory growth. We may say, therefore, that failure is certain to be invited when such important facts are disregarded, or overlooked. The degree of success which it is possible to win on any farm is in direct proportion to the practical knowledge possessed by the farmer concerning the soil and its adaptation to crops. A thorough knowledge of the soil is as essential to the farmer as a knowledge of merchandise and business methods is to the merchant.

The State of Wisconsin, working in coöperation with the United States Department of Agriculture, is making a careful study of soils and agricultural conditions throughout Wisconsin, and is preparing soil maps and soil reports of all counties in the State. A soil map shows the location and extent of the different kinds of soil. Tracts of 10 acres and over are mapped, but often areas of even smaller extent are shown. The soil map is prepared by trained men, who go over a county thoroughly, and examine the soil by making a sufficient number of borings to a depth of 36 inches to keep account of all variations. A report is also made, to accompany and explain the map, and this is based upon a careful study of the soils within the region surveyed, and upon such other features as have a direct bearing upon the agriculture of the area.

It is the object of this survey to make an inventory of the

soils of the State, and to be of practical help to farmers by locating and describing the different soils, by determining their physical character and chemical composition, and by offering suggestions for their management, based upon the work of the Soil Survey within the area, covered in the report, and upon the results of field tests made by the Experiment Station.

Soil fertility depends upon two factors: first, upon the physical characteristics of the soil, such as water holding capacity, workability, etc., and second, upon the chemical composition of the material composing the soil. The chemical composition depends upon the mode of origin of the soil, and the source of material from which the soil is derived.

Water holding capacity, and other physical properties of soil all depend chiefly upon *texture*, which refers to the size of the individual soil grains, or particles. A coarse sandy soil, for example, will not retain moisture so long as a loam soil, or clay loam, because the finer the soil grains, the greater will be the total soil-grain surface area to which moisture may adhere. Texture is determined in the field by rubbing the soil between the thumb and fingers, and with experience one soon becomes expert at judging the size of soil grains. This field judgment is verified in the laboratory by a *mechanical analysis*, which is made by a simple method of separating soil grains into different groups, of which there are seven. These are known as clay, silt, very fine sand, fine sand, medium sand, coarse sand, and fine gravel.

A chemical analysis is also made of the soil to determine the amounts of various essential plant-food elements which are present. A chemical analysis shows whether the soil contains a large store of plant food, or only a small quantity, and it indicates which kinds of plant food will probably be needed first. The amount of organic matter in the soil is also determined, and tests are made to show conditions relative to soil acidity.

SOIL CLASSIFICATION.

Soils are grouped according to texture into soil classes, a *soil class* being made up of soils having the same texture, though differing in other respects. A fine sand, for example, may be light colored and of alluvial origin, while another fine sand may be dark in color and of residual origin, while a third fine sand may have been blown into sand dumes by the wind, yet all of these soils would belong to the same class, because the greater proportion of the soil grains have the same size or texture. Thus we may have different kinds of clays, loams, sands, etc., and the class to which any soil will belong depends upon the size of the individual soil grains of which it is composed, and not upon its color, origin, topographic position, or agricultural value.

SOIL CLASSES

SOILS CONTAINING LESS THAN 20% SILT AND CLAY

Coarse sand.—Over 25% fine gravel and coarse sand, and less than 50% of any other grade of sand.

Sand.—Over 25% fine gravel, coarse and medium sand, and less than 50% fine sand.

Fine sand.—Over 50% fine sand, or less than 25% fine gravel, coarse and medium sand.

Very fine sand.—Over 50% very fine sand.

SOILS CONTAINING BETWEEN 20–50% OF SILT AND CLAY

Sandy loam.—Over 25% fine gravel, coarse and medium sand.

Fine sandy loam.—Over 50% fine sand, or less than 25% fine gravel, coarse and medium sand.

Sandy clay.—Less than 20% silt.

SOILS CONTAINING OVER 50% OF SILT AND CLAY

Loam.—Less than 20% clay, and less than 50% silt.

Silt loam.—Less than 20% clay, and over 50% silt.

Clay loam.—Between 20 and 30% clay, and less than 50% silt.

Silty clay loam.—Between 20 and 30% clay, and over 50% silt.

Clay.—Over 30% clay.

Soils may be grouped in another way. Where soils are closely related through similar sources of the material from which derived, mode of origin, topographic position, etc., so that the different soils constitute merely a graduation in texture of otherwise uniform material, such a group is called a *soil series*. It corresponds to the family which is made up of different individuals having the same parentage. The Miami series, for examples, includes light colored, glacial material where the soils

have been derived largely from the underlying limestone, and the soils in the series range in texture from a clay loam to sand and gravel. The Plainfield series includes light colored soils in regions where no limestone is present, and where the material occurs as outwash plains or stream terraces. The soils in this series also have a wide range in texture. The name used for a soil series usually indicates the locality where that particular series was first recognized and mapped by the Soil Survey.

By uniting the name of the *soil class,* which refers to texture, with the name of the *soil series,* which refers chiefly to origin, we get the *soil type,* which is the basis or unit of classifying and mapping soils. A *soil type,* thus, is a soil which is uniform throughout its entire extent in texture, color, topographic position, and other physical properties, and having a distinct agricultural unity, that is, being adapted to the same crops, and requiring the same treatment. It is also uniform in the source of material from which it is derived, and the mode of origin which, taken together, determine the chemical composition. Since the soil type is the unit in classifying and mapping soils, and the basis upon which experimental work should be conducted, every farmer should be familiar with the soil types on his farm, and their leading characteristics.

SOIL SURVEY OF WAUKESHA COUNTY, WISCONSIN.

CHAPTER I

GENERAL DESCRIPTION OF THE AREA

Waukesha County is located in the southeastern part of Wisconsin and comprises an area of 560 square miles, or 358,400 acres. The surface features of the area are characteristic of a glacial region, and the topography varies from level to rolling and hilly. The most pronounced topographic feature is the Kettle Moraine, which traverses the county in a general direction 15 degrees west of south, passing through the townships of Merton, Delafield, Genesee, the southeast part of Ottawa, and Eagle. This ridge varies in width from 1 to 4 or 5 miles and includes the roughest part of the area. In the southwestern part of Delafield Township, on Government Hill, it attains an elevation of 1,233 feet above sea level, which is the highest point in the county, and 350 feet above the level of Summit Prairie. The average elevation of the area is between 900 and 1,000 feet. The topography in the immediate vicinity of Government Hill is extremely rough and broken.

Another moraine belt extends to the northeast from the village of Mukwonago, passing through the township of Vernon and into the southwest corner of New Berlin. Throughout a large part of Oconomowoc and Summit Townships the surface is level to undulating.

Extending to the east and northeast of Eagle is a level tract of considerable size, commonly spoken of as prairie. Another similar occurrence, though of much smaller extent, is found immediately south of Waukesha. Other level to undulating

areas are found in the eastern part of Merton, the eastern and northern parts of Lisbon, the northwestern part of Delafield, and the southern and eastern parts of Muskego Townships.

There are a number of marshes in the area, the largest occupying a portion of Eagle and Ottawa Townships; another of considerable size extends north from Mukwonago along Fox River. Other smaller swamps are found in all parts of the survey. The remainder of the county is rolling to hilly. In general, it may be said that the southern half of the county is rougher than the northern.

The Fox River is the largest drainage course in the county. It heads in the northeastern part of the area, meanders in a southwesterly direction to near Mukwonago, thence, turning sharply eastward to Big Bend, it flows south and leaves the county. It empties into the Illinois River and eventually into the Mississippi. The Fox River receives practically all the drainage from the north-central, central, southern, and southeastern parts of the county. The western and northwestern parts are drained by the Scuppernong, Bark, and Oconomowoc Rivers, the waters of which find their way to the Mississippi through Rock River. The extreme northeastern corner is traversed by the Menominee River, and Root River passes through the eastern border of New Berlin Township. Both of these streams flow into Lake Michigan. A few of the streams afford a small amount of water power, which is utilized chiefly for running grist-mills.

The first settlement in Waukesha County was made in 1834, at Prairie Village, on the present site of Waukesha. Wisconsin Territory was organized in 1836. The county of Waukesha was established from a part of Milwaukee County in 1846.

The first settlers came chiefly from New England, New York, Pennsylvania, Ohio, and Illinois. Later a number of foreign settlements were established within the county. At the present time persons of German descent are the most numerous within the area, while the English are probably second in numbers. All parts of the county are now thickly settled, well developed, and supplied with telephone and rural free delivery.

Waukesha, an up-to-date city of about 8,000, is situated in the east-central part of the area, in the midst of a good agri-

cultural district. It is the county seat, a thriving business center, and a distributing point for farm implements, seeds, and general supplies. It has long been famous for its mineral springs. Oconomowoc, in the northwestern part of the area, is the second town of importance. It has a population of about 3,000, is built between two beautiful lakes, contains many fine summer homes, and is surrounded by a good farming country. Okauchee, Nashotah, Delafield, Pewaukee, Menomonee Falls, Eagle, Mukwonago, North Lake, Muskego, Wales, and Elm Grove are smaller towns and villages scattered throughout the county.

The county is well supplied with steam and electric roads. There are no steam roads, however, in the southeast part of the county, and, as the electric lines are not permitted to carry freight or express, the farmers of this region haul most of their produce to Milwaukee by team. All other parts of the area are within easy reach of shipping points.

The dirt roads throughout the county are kept in very good condition. They are piked by the use of large road-grading machines and crowned with gravel or crushed rock. There is an abundance of good road-building material in nearly all parts of the area. The mileage of improved highway is increasing each year. There are no toll roads in Waukesha County.

The towns and cities within the county afford a limited market for the products of the farm and dairy. The chief markets are Milwaukee and Chicago, both of which are within easy reach. From Waukesha to Milwaukee it is but 20 miles via the Chicago & North Western, and but 100 miles to Chicago via the Soo line.

SOILS

Waukesha County, in common with all northern and eastern Wisconsin, owes the general character of its surface to glacial action. Three more or less distinct periods of glaciation have influenced the geology and topography of the state. The products of these several invasions of the ice are known as the Older or Pre-Wisconsin Drift, the Early Wisconsin Drift, and the Late Wisconsin Drift. It is with the most recent period of

glaciation that we are chiefly concerned in this county, since it brought down and deposited most of the material which covers the surface of this region. The Late Wisconsin Drift was formed by the advance and retreat of four contemporaneous ice lobes known as the Superior, Chippewa, Green Bay, and Lake Michigan Glaciers. The two last named were confined to the eastern part of the State and combined to mold the surface features of a large area, including Waukesha County.

The direction of the main body of the Green Bay Glacier was to the southwest, though the portion reaching into Waukesha, Jefferson, and Walworth Counties had a direction varying from south to southeast. The Lake Michigan Glacier advanced southward along the lake basin, and on the west developed laterally what is called the Delavan Lobe. Where the Green Bay Glacier came into contact with the Delavan Lobe what is known as the Kettle Moraine or Medial Moraine was formed. This consists of a very conspicuous range of hills extending to the northeast from a point near Delavan, in Walworth County, to about the center of Kewaunee County. It crosses Waukesha County and forms the most noticeable feature of the area. Outside of the Kettle Moraine, till, deposited by the ice sheets, is known as the ground moraine. The topography here varies from level to rolling and hilly. There are a number of "prairies" in the county, which were formed by streams coming from beneath the great ice sheet, and are known as outwash plains. Rough, gravelly areas are found in various parts of the survey, frequently having the form of rounded hills or elongated ridges. There are also large areas where the surface of the drift is gently rolling.

On the retreat of the great ice sheets the melting of massive blocks which had broken off, the issuing of water from under the glaciers, and the dumping of glacial débris across drainage channels resulted in the formation of numerous kettlelike depressions or holes from a few rods to several miles in extent. Many of these filled with water and formed the beautiful lake region of Waukesha County. Many of the smaller depressions contain no water and are spoken of as "potholes" or "kettle holes."

The glacial drift over Waukesha County varies in depth from a few feet to over 300 feet. There appear to be several preglacial valleys in the area, and one of these is traversed by the Fox River between Waukesha and Big Bend. At some points here the drift is known to be at least 300 feet deep. The rock encountered in wells in the floor of these valleys is in one case Cincinnati shale; in another Potsdam sandstone. The rock upon which the glacial drift throughout the greater part of the county rests is the Niagara limestone, which overlies the Cincinnati shale. This outcrops extensively at Waukesha and Lannon, where large quarries have long been in operation, and also at numerous other places throughout the county. In Lisbon and the western part of Menominee Townships, the rock is frequently encountered at from 2 to 3 feet below the surface.

Twenty soil types, including Peat and Meadow, have been recognized and mapped in Waukesha County. The material of which they are composed has all been derived from glacial till, though some of it has been reworked and redeposited by water and modified by the incorporation of organic matter since its first deposition. The glacial drift consists of a mixture of sand, gravel, clay, and bowlders. The greater proportion of this material consists of ground-up limestone and the resulting soils are naturally more productive than where no limestone is found.

The Miami series of soils is the most extensively developed. It comprises light-colored soils originally covered by a forest growth. It is found covering large tracts throughout eastern Wisconsin, in Minnesota, Michigan, Ohio, Indiana, and Illinois. The types in this series mapped in Waukesha County are the silt loam, clay loam, loam, fine sandy loam, sand, gravelly sandy loam, and gravel.

The Plainfield series consists of light-colored soils composed of assorted glacial material, which occurs in the form of outwash plains and filled-in valleys. The types belonging to this series recognized in Waukesha County are the silt loam, loam, fine sandy loam, and sand.

The Waukesha series includes the dark-brown to black soils occupying outwash plains and terraces. These areas are com-

monly spoken of as prairies, though portions of them were originally wooded. Two types of this series, the loam and gravelly loam, were encountered in the survey of Waukesha County.

The Carrington series, which is developed over a very small area, includes dark-colored soils of glacial origin. Two types, Carrington loam and clay loam, were mapped.

The Clyde series includes dark-colored soils occupying low, poorly drained depressions, marshes, and old lake beds. They contain a high percentage of organic matter, but much more mineral matter than Peat (with included areas of Muck). The types recognized as belonging to this series are Clyde silty clay loam, loam, and sandy loam.

The material mapped as Peat (with included areas of Muck) occupies swamps, marshes, and old lake beds. Where the vegetable matter has reached an advanced stage of decomposition, and where there is considerable mineral matter incorporated with it, it is true Muck, but in those areas in which the material is still fibrous or contains but little mineral matter it is Peat. On account of the lack of uniformity and the constant gradation of one phase of material into the other, it was not feasible to separate the two.

Meadow includes narrow, low-lying strips of land along streams which overflow their banks annually. The soil is variable and can not be classed with any of the other established types. It would be difficult to drain the tracts of soil mapped as Meadow.

The names of the different types, together with their actual and relative extent, are given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami silt loam	82,176	22.9	Plainfield fine sandy loam	8,192	2.3
Peat (with included areas of Muck)	57,600	16.1	Plainfield loam	4,160	1.2
			Plainfield sand	2,752	.8
Miami gravelly sandy loam	51,520	14.4	Miami fine sandy loam	2,624	.7
Miami clay loam	30,848	8.6	Miami sand	1,920	.5
Plainfield silt loam	24,064	6.7	Meadow	1,728	.5
Miami loam	22,592	6.3	Clyde sandy loam	1,088	.3
Miami gravel	20,672	5.8	Waukesha gravelly loam	704	.2
Clyde silty clay loam	16,960	4.7	Carrington loam	640	.2
Clyde loam	14,464	4.0	Carrington clay loam	256	.1
Waukesha loam	13,440	3.7	Total	358,400	....

CHAPTER II.

GROUP OF CLAY LOAM AND SILT LOAM SOILS

MIAMI CLAY LOAM

Description. The surface soil of the Miami clay loam consists of a brownish gray silt loam or silty clay loam, 8 to 10 inches deep, underlain by a yellowish-brown clay, which at 24 inches grades into a stiff, tenacious, chocolate-brown or dull-red clay. The depth of the surface soil is variable, as erosion has removed from some of the higher elevations the silty covering, which has accumulated on the lower slopes to considerable depth. The subsoil of the Miami clay loam closely resembles the subsoil of the Superior clay loam in a number of places, and as work progresses eastward an arbitrary line must be drawn between the Miami clay loam and the Superior clay loam.

In the vicinity of Fussville the type is somewhat lighter than typical. The surface consists of a brown heavy loam or light clay loam, underlain by a yellowish clay in which seams of quicksand are found in the lower subsoil. Along the edge of the main body of the Miami clay loam and in the broken areas in the southeastern part of the county the surface is more silty than elsewhere. The boundary line between the Miami clay loam and the Miami silt loam is more or less arbitrary. Scattered over the type are to be found small pebbles and in some places a few larger stones, mostly of limestone material. There are also a few gravel beds, but these are never as numerous as is the case throughout the silt loam and the loam types.

Extent and distribution. The main body of Miami clay loam extends across the county in a north and south direction in a strip about 4½ miles wide from the north county line to near New Berlin. Thence southward it is developed only in small separate areas.

Topography and drainage. Except along streams, where the surface becomes somewhat broken and hilly, this type is gently rolling to rolling. The surface drainage is fairly good. In depressions and draws tile drains would be very beneficial. Even over much of the gently rolling land tiles could be installed to good advantage. The reclamation of small potholes and wet swales will mean large regular fields instead of small, obstructed, irregular ones. Tile drainage also means earlier cultivation in the spring and a warmer soil, conditions which are especially necessary for the successful growing of corn.

Origin. Miami clay loam is derived largely from the weathering of the glacial till which covers this region, but it is probable that the heavy red clay forming the subsoil is related to the soils of the Superior series and may therefore be partly of lacustrine origin.

The subsoil is highly calcareous but a large amount of the carbonate of lime has been leached from the surface soil. The type, however, is not in an acid condition.

Native vegetation. The original timber growth consisted of red, white, and bur oak, hickory, maple, ash, elm, and other hardwoods. At present only small areas are forested, and these are woodlots.

*Agricultural Development**. General farming, with a few special crops, is practiced on Miami clay loam. The chief cereal crops are corn, oats, and rye. The growing of barley has declined on account of the low yields obtained in recent years, but with proper rotation and better seed selection this crop could be grown successfully again. Barley gives an average yield of 25 to 30 bushels per acre.

If the season is not too late and wet, corn does very well on this type, giving an average yield of 35 to 50 bushels per acre. At present most of the corn is cut in the glazed stage for silage, Fodder corn yields from 12 to 20 tons per acre, with an average of 15 tons.

This type is well adapted to oats and a large acreage is sown. The average yield is 40 bushels per acre, but as high as 65

* For information on the management and methods of improvement of Miami clay loam, see page 28.

bushels is often obtained. A limited acreage is devoted to the growing of rye, which yields 15 to 25 bushels per acre, with an average of about 20 bushels. This soil is well adapted to grasses, clover, and alfalfa. Clover and timothy are grown more extensively than other hay crops, but the acreage of alfalfa is gradually increasing. Clover yields 1½ to 2½ tons; when mixed with timothy 1 ton to 1½ tons. Alfalfa thrives on the more rolling areas and yields from 2 to 3 tons per acre, with a maximum yield of 4 to 5 tons. The abundant growth of sweet clover along the roadsides is an indication that most of the soils are well inoculated with the alfalfa bacteria. Some alsike clover is grown, chiefly for seed. It is a very uncertain crop, yielding from 2 to 8 bushels per acre, with an average of 3 to 4 bushels.

Sugar beets are grown quite extensively on the area north of Brookfield P. O. Nearly every farmer plants the crop, the acreage ranging from 2 to 10 acres. Beets are grown more extensively on this type than on any other in the area. The average yield is from 12 to 15 tons per acre, although as much as 18 to 20 tons has been obtained. Beets grown on this soil have a higher sugar content, from 14 to 16 per cent, than beets grown on any of the other types in the area. A heavy application of manure and thorough tillage are necessary for the successful growing of sugar beets.

Around Elm Grove some of this type is devoted to the production of cabbage and cauliflower. Cabbage yields from 10 to 18 tons per acre, with an average of about 13 tons. The average gross return from cauliflower is about $150 per acre. These products are marketed in Milwaukee. Potatoes are grown on a commecial scale by a few farmers, but in most cases they are grown only for home consumption, the soil being too hard and compact for good results. The ordinary yields per acre range from 5 to 150 bushels.

Miami clay loam can be cultivated only under a limited range of moisture conditions. If worked when the moisture conditions are the most favorable, the soil breaks up into granules; but if cultivated when too wet, lumps form which are very difficult to pulverize. When dry, the soil becomes very hard

VIEW OF MIAMI SILT LOAM NORTHEAST OF PEWAUKEE, SHOWING CHARACTERISTIC ROLLING TOPOGRAPHY, TYPICAL FARM BUILDINGS, AND HIGHLY IMPROVED FIELDS.

Dairying and general farming are the leading types of agriculture. This is the most extensive soil in Waukesha County.

and often almost impossible to cultivate. This type is the most difficult to handle of all the soils of the county. Checks and cracks one-half inch in width are commonly found on this soil. A soil mulch created by continuous cultivation is a good way of retaining the moisture. With proper cultivation crops on this type will withstand drought for a long period, but if no mulch is provided they will suffer sooner than on some of the lighter soils of the series.

MIAMI SILT LOAM

Description. As found in Waukesha County the surface soil of Miami silt loam, to a depth of 10 to 14 inches, consists of a grayish to yellowish brown silt loam. This is underlain by a yellowish silty clay loam to a depth of 18 to 20 inches, where a yellowish-brown, gritty clay loam is encountered. On the rolling areas of the type, in particular, there is present upon the surface a small quantity of gravel and some larger stones and bowlders. Most of these have been removed from the cultivated fields. A large percentage of the rock fragments are limestone. On knolls and hills the surface soil has often been eroded, leaving exposed the brownish clayey material. In depressions and draws the surface soil has accumulated to considerable depth and is usually of a darker color.

While the greater part of the type in this area answers the description given above, there are some variations worthy of notice. In the vicinity of Lannon the soil is very shallow, the underlying limestone being encountered at from 12 to 18 inches. The rock is exposed in a few places and a number of quarries are in operation in that region. In the southeastern part of the county the soil is not quite as silty as elsewhere; the subsoil is somewhat heavier, and contains less gravel than the type as a whole. In the areas southeast of New Berlin the soil is very floury in appearance, being very silty and of a whitish color. These areas are rather low in organic matter and less productive than the average of this type of soil. The areas northeast of Waukesa approach Miami loam, and the boundary lines here are somewhat arbitrary. In the depressions the soil is a silty loam, while on the higher land it is more like a loam.

Around the edge of kettle holes the soil is often quite gravelly at the surface, and is droughty.

Extent and distribution. Miami silt loam is one of the most extensive and important types in the county. It is confined chiefly to the northern half, giving way to Miami clay loam along the eastern border, grading into Miami loam toward the south, and merging into Plainfield silt loam of the outwash plains to the west. The type is interspersed with areas of gravel and gravelly loam, especially in the northwestern part of the county.

Topography and drainage. The topography varies from undulating to rolling. In the vicinity of Pewaukee the surface is rolling, approaching a hilly topography. The same is also true of some of the areas northeast and southeast of Waukesha. In a number of places where the surface is the most broken, erosion has become a factor in farm management. The surface soil of some of the steeper slopes has been washed away, and gullies formed. Many of the eroded fields are kept constantly in grass, and it is advisable that such places should always be protected by a cover crop of some kind. Contour cultivation, keeping a field in grass as much as possible, and the growing of crops which do not require intertillage, are means by which erosion may be held in check.

Owing to the topography and also, over a greater part of the type, to the gravel in the subsoil, the natural drainage is good. Narrow draws and depressions are an exception, but these can usually be drained by a single line of tile. Along the margin of kettle holes, where the gravel appears at, or comes close to the surface, the type is inclined to be droughty. For a short time in early spring, frozen ground in kettle holes and small depressions will not permit the escape of water, and some damage is occasionally done to clover or alfalfa in such places. Some of this damage could be prevented by tile drains.

Origin. This type of soil is derived from the ground moraine, here deposited chiefly by the Lake Michigan Glacier, though a portion of it was left by the Green Bay Glacier.

Over a portion of the type the surface soil is in an acid condition. The subsoil, however, usually contains a considerable amount of the carbonate of lime.

Native vegetation. The original timber growth on this type consisted of white, red, and bur oak, hickory, ironwood, ash, and basswood, with some maple, butternut, walnut, elm, and beech. By far the greater part of Miami silt loam is now cleared and in a high state of cultivation.

*Agricultural development.** The greater proportion of the type is devoted to general farming and dairying. It is considered a good soil for this type of agriculture. Fodder corn yields from 8 to 15 tons per acre, and field corn from 35 to 70 bushels per acre. In many sections oats are grown more extensively than other crops. The soil is well adapted to the production of this crop. Yields range from 35 to 75 bushels, with an average of 45 bushels per acre. Barley is grown to some extent, but owing to improper rotations and too little attention to the selection of seed, the yields have depreciated and the tendency is to reduce the acreage. The average yield is about 30 bushels per acre, with yields considerably lower where the crop has been grown continuously. Small tracts are devoted to rye, with yields of from 20 to 25 bushels per acre. The acreage devoted to wheat is very small. The yields during the season of 1910 were between 20 and 30 bushels per acre, which is somewhat above the average for a series of years. Clover does very well, and yields of 2½ tons per acre are not uncommon. Alfalfa is coming into favor because of its large yields and high feeding value. Three cuttings are secured, and the average yield for the season is 3 tons per acre, though as high as 4 and 5 tons per acre have been obtained. The acreage is limited at present, but it is being gradually extended as this soil is unusually well adapted to alfalfa.

Peas, sugar beets, and potatoes are the leading special crops on this type. The growing of peas is largely confined to a strip of land embracing an area of about 50 square miles on both sides of the Soo Line north of Waukesha. A canning factory located at Waukesha takes most of the crop. The gross returns per acre range from $30 to $45. When cured or put in the silo the vines make a good feed for stock. Sugar-beet culture is

* For information on the management and methods for the improvement of Miami silt loam see page 28.

chiefly followed in the northeastern part of the silt loam area in the northern part of the county. On account of the physical character of the type, beets are more easily raised and at a lower cost than on Miami clay loam. Yields range from 10 to 13 tons per acre, though larger yields are frequently obtained. Potatoes are grown successfully on this soil, but not on a commercial scale.

Miami silt loam is an easier soil to cultivate than the clay loam, and can be worked under a wider range of moisture conditions. Cultivation when wet causes some baking and clodding, and of course this should be avoided as much as possible. The physical character of this soil is such that a good mulch can be kept on the surface by judicious cultivation, and a very loose and mellow seed bed secured.

The most common rotation practiced consists of corn one year, oats or barley one year, or one year for each of these crops, clover for hay one or two years, and pasture one year. On a number of farms systematic crop rotation is not followed.

PLAINFIELD SILT LOAM*

Description. As found in Waukesha County the surface soil of Plainfield or Fox silt loam consists of an ashen-gray to light-brown silt loam, having an extremely smooth and velvety feel, and extending to a depth of 8 to 14 inches. This is underlain by a yellowish-brown silty clay loam, becoming rather compact in the second foot. At from 2 to 3 feet gravel in a clay loam matrix or a gravel bed is encountered. In a number of places this comes to within 12 or 18 inches of the surface, and especially along the edge of kettle holes the soil is shallow and very gravelly.

In Summit Township an area of the type varying somewhat from the above description is found. The surface consists of a yellowish-gray or ashen-gray silty loam, containing a high percentage of fine and very fine sand, and extending to a depth of 8 to 12 inches. It is underlain by a yellowish silty loam

* The soil type here described as Plainfield silt loam, which contains limestone material in the subsoil, will in the future be classified as Fox silt loam, and the Plainfield series will be confined to the light colored soils occupying outwash plains and river terraces where the material is non-calcareous.

FIG. 1. VIEW OF MIAMI CLAY LOAM 7 MILES EAST OF WAUKESHA. SHOWING UNDULATING TO GENTLY ROLLING SURFACE AND HIGHLY IMPROVED FARMS.

This is the heaviest upland soil in Waukesha County.

WISCONSIN GEOL. AND NAT. HIST. SURVEY. PLATE II.

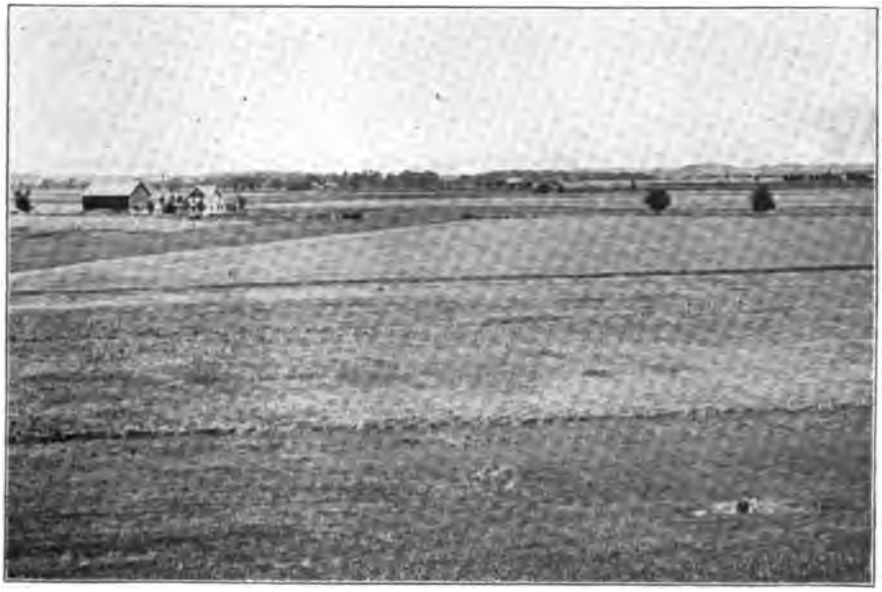

FIG. 2. VIEW OF PLAINFIELD SILT LOAM NORTHEAST OF OCONOMOWOC. SHOWING LEVEL, PLAIN-LIKE SURFACE, AND TYPICAL SET OF FARM BUILDINGS.

This type of soil is all highly improved.

or light clay loam, which contains a high percentage of sand and gravel, and which grades into gravel at about 18 inches. The gravel under the entire type consists largely of limestone material, and the beds are a heterogeneous mixture of gravel, sand, cobblestones, and bowlders, which in many places show stratification.

Cultivation of this soil is easy, and owing to the underlying gravel it can be worked under a wide range of moisture conditions. The color of the soil indicates a low organic matter content, and the growth of sorrel and the litmus test indicate slight acidity.

Extent and distribution. Plainfield silt loam is confined to the northwestern part of the county in Oconomowoc and Summit Townships. It resembles Miami silt loam in having a silty surface soil and some gravel in the subsoil. It differs, however, in topography and the method of deposition.

Topography and drainage. The surface of Plainfield silt loam is level to slightly undulating. On account of the underlying gravel the natural drainage is good. Where the gravel comes close to the surface, as is the case along the margin of the pot-holes, which are numerous, the type is inclined to be drought. Crops on the light phase in Summit Township are apt to suffer somewhat during the longest dry spells.

Origin. Plainfield silt loam is derived from glacial material, the greater portion of which has been reworked by streams issuing from glaciers and deposited as overwash plains. The underlying gravel shows stratification in many localities and this is an indication of the method of deposition. The gravel consists largely of limestone.

Native vegetation. The original timber growth consisted chiefly of oak. Where this growth was scrubby and scattered the term "oak openings" was applied. While a large part of the Summit Township area is included in what is called Summit Prairie, it was not originally entirely treeless.

*Agricultural development.** Plainfield silt loam is considered a good general farming soil, and nearly all the type is under cultivation. Corn yields from 30 to 70 bushels per acre;

* For information on the management and methods for the improvement of Plainfield silt loam see page 28.

oats from 35 to 75, with an average of 45 bushels per acre. Oats are grown more extensively in Oconomowoc Township on this soil, than in any other part of the county. The average yield is about 35 bushels per acre. Rye is grown to some extent and yields about 24 bushels per acre on the average. Wheat is grown only to a very limited extent. Clover yields from 1½ to 3 tons per acre, and clover and timothy from 1 ton to 2 tons per acre. Alfalfa is grown successfully and yields from 2 to 4 tons per acre. The acreage is being increased gradually. No special crops are grown upon this soil, except in the home gardens, the entire area being devoted to a general farming and dairying.

A common rotation consists of corn, oats, or barley, followed by clover and then by pasture one year, and back to corn. While the agriculture is in general highly developed, there are, nevertheless, a number of farms on which no systematic crop rotation is practiced.

No commercial fertilizers are used, but liberal applications of stable manure are given every three or four years.

The following table gives the average result of mechanical analyses of the soil and subsoil of Plainfield silt loam:

Mechanical analyses of Plainfield silt loam.

Description.	Fine gravel.	Course sand.	Medium sand.	Fine sand.	Very fine sand	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0.6	2.6	3.1	4.1	2.8	76.2	10.8
Subsoil...............	.7	2.9	3.9	4.9	3.7	66.9	16.6

CARRINGTON CLAY LOAM

Description. Carrington clay loam consists of a dark-brown or black clay loam, 8 to 12 inches deep, underlain by a light-brown clay loam, or clay, extending to a depth of 18 to 24 inches, where a compact brownish clay is encountered. In depressions and swales the subsoil becomes more or less mottled and impervious to water. There is little or no coarse material

in either soil or subsoil. When properly handled the soil has a friable structure; but if cultivated when too wet, it clods and bakes. It contains a relatively high percentage of organic matter, which gives the characteristic black color. On the knolls the soil is rather light in color and possesses more of the characteristics of soils of the Miami series.

Extent and distribution. Carrington clay loam occupies only a small tract in the extreme southeastern corner of the county, extending into Racine County, where it is the predominating soil type.

Topography and drainage. It occupies a gently rolling to rolling topography, and is rather poorly drained. Depressions and swales would be greatly benefited by tiling, and even the rolling lands would be improved. Statements of farmers in Racine County show that tile drainage on such land is a profitable investment.

Origin. The soil is derived from glacial material which many centuries ago was subjected to wet conditions, favoring the growth and decay of water-loving vegetation.

Native vegetation. The type was originally timbered with oak and other hardwoods. Practically all of it is cleared and under cultivation at the present time. While the Carrington soils are usually prairie lands in the glaciated region, this section is an exception, in that it was timbered.

Agricultural development. General farming is practiced. The type is adapted to a variety of crops. The chief crops grown are corn, oats, timothy, and clover. Corn does well, giving an average yield of 40 bushels per acre. Oats are grown quite extensively, the yields ranging from 25 to 60 bushels per acre, with an average of 40 bushels. Timothy and clover also do well, as is shown by the average yield of 1½ tons per acre. In Racine County this type has been extensively used for growing cabbage and sugar beets. Cabbage yields 12 to 15 tons, and beets 8 to 12 tons per acre.

METHODS OF IMPROVEMENT FOR MIAMI CLAY LOAM, MIAMI SILT LOAM, PLAINFIELD SILT LOAM, AND CARRINGTON CLAY LOAM.

There are a number of types in Waukesha County which are so closely related in texture, structure, and agricultural possibilities, that from the standpoint of improvement and management they may be considered in groups, rather than as individual types.

The four types of soil in this group are much alike in certain chemical respects, though each has its individual characteristics in other respects. They run rather high in the mineral elements, phosphates, potassium, calcium, and magnesium. The surface 8 inches will average about 1,100 pounds of phosphorus per acre, which is from 25 to 50 per cent. higher than in the sandy and sandy loam groups of soils.

In potassium there is considerable variation. Miami clay loam, especially in the subsoil, is very rich in this element. The average amount in the surface 8 inches per acre is approximately 53,000 pounds. In Miami silt loam the average is about 43,000 pounds, and Plainfield silt loam is somewhat lower; but all have sufficiently abundant supplies of this element to supply all heavy crops when the soil contains the necessary amount of actively decomposing organic matter to render it available.

In nitrogen and organic matter there is more variation. Miami clay and silt loam, and Plainfield silt loam have a rather small amount of organic matter and consequently small amounts of nitrogen, the average for these three types being less than 3,000 pounds per acre in the surface 8 inches. Carrington clay loam, on the other hand, as its color indicates, has a much larger amount of organic matter and nitrogen, the average being somewhat more than twice that in the other three types of soil. It must be remembered, however, that even dark prairie soils which have been cultivated for a number of years without the use of manure or other vegetable matter will loose the most active part of their organic matter, and even though they still retain enough to give them a good dark color, the organic matter is of a resistant character, and the nitrogen and inorganic

matter—phosphorus, potassium, and calcium—do not become available to crops with sufficient rapidity. Moreover, the large crops which these soils have usually produced for a number of years after being first broken have frequently exhausted the more readily available phosphorus to such an extent that the development of a high degree of fertility in them now requires the use of some form of phosphate fertilizer as well as the use of a system of rotation and manuring which will supply the necessary active organic matter.

The supply of calcium carbonate in all flour of these types of soil was originally very large on account of their formation in large part from limestone rock by the grinding action of glaciers. Their subsoils still contain large amounts of lime and magnesium carbonate, with the exception of that of the Plainfield silt loam, which has in the subsoil only moderate amounts of this material. The surface of these types, however, have been subjected to leaching for thousands of years and this has, to a considerable extent, removed the carbonate from the surface 6 to 12 inches, so that acidity has developed in patches over this entire section. This is particularly true of the Carrington clay loam, the larger amount of organic matter of which has caused a larger solution of the carbonate than occurred in the other soils containing smaller amounts of vegetable matter. Farmers having difficulty in getting a good catch of clover or alfalfa should test their soil for acidity.* The large supply of lime carbonate existing in the subsoils of practically all of the area covered by the four types named will undoubtedly greatly lessen the amount of lime which may be needed to maintain them in a sweet condition.

* As a number of the soils in this area are in an acid condition and would be greatly benefited by the application of lime, every farmer should know how to test his soil for acidity. "A very simple and reliable method to detect soil acidity is by the use of blue litmus paper, which can be secured of any good druggist. Take a handful of moist soil and form it into a ball. Break the ball into halves and place a piece of blue litmus paper in the center on one of the halves, and cover over with the other half. After 5 minutes break the ball, and if the paper is pink in spots or over the whole end, the soil is acid." "Soil acidity is also usually indicated by the growth of certain weeds, such as sheep sorrel, horse-tail rush, corn spurry and wood horse-tail." For more information on this subject see Bulletin 230 of the Wisconsin Agricultural Experiment Station.

In the management of these types it should be kept in mind that, with the exception of the Carrington clay loam, the surface soil of all of the types in this group is light colored and deficient in organic matter. An effort should be made to gradually increase the supply of organic matter by supplementing the stable manure with green manuring crops. Legumes are best for this purpose. The plowing under of such crops will tend to loosen the heavy soil, and more nitrogen will be supplied than if other crops are used.

Wherever an acid condition is sufficiently marked to interfere with the growing of crops, ground limestone should be applied at the rate of from 1,200 to 1,500 pounds per acre. These types, and especially the Carrington clay loam, will also respond to applications of rock phosphate. This may be applied at the rate of 500 to 600 pounds per acre for the first application, and about half this amount once during each rotation. It may be spread upon the land by mixing it with the manure or by putting it on top of the manure in the manure spreader. Phosphate fertilizers usually give best results where the soil is acid.

Careful attention should be given to crop rotations, and efforts should be made to follow only such a system as will tend to increase, or at least maintain, the soil fertility. Thorough cultivation is more important on these heavy types than on the lighter soils of the county. Fall plowing, especially of sod, is advisable where there is no danger of erosion. The seed bed should always be carefully prepared, and with intertilled crops, such as corn, a good mulch should be kept, to check the loss of soil moisture. The growing of alfalfa could be profitably extended, and some special crops, including peas, could well be raised more extensively.

CHAPTER III.

GROUP OF LOAM SOILS

MIAMI LOAM

Description. Miami loam consists of a yellowish to brownish-gray medium loam, 8 to 12 inches deep, underlain by a brownish clay loam, becoming rather compact at a depth of 2 feet, and grading into a gritty clay loam at 24 to 30 inches. The lower subsoil frequently becomes very gravelly, and a gravel bed is sometimes encountered at 3 feet. On some of the knolls a sprinkling of gravel is sometimes found upon the surface, and over the rougher portion of the type, bowlders were originally found. Most of these have been removed from the cultivated fields.

The type is somewhat variable, though the areas departing from the type are too limited in extent to be classed as separate soils. There are a number of patches, especially in the southern and southeastern parts of the county, where the soil contains considerable sand, and the subsoil more gritty material than is typical. Along the region of contact with the clay loam, the subsoil, especially, becomes quite heavy; and where it joins the Miami silt loam, the boundary is often arbitrary. Around the margin of kettle holes, gravel frequently comes very near the surface.

The type is confined chiefly to the southern and eastern parts of the county. The largest areas are found southwest of Waukesha, and in the townships of Vernon and Muskego. Besides these there are a number of smaller patches scattered throughout the southern and eastern parts of the survey.

Miami loam occupies a gently rolling to rolling topography, and in a few places becomes quite hilly. The natural drainage is good, except in draws and small depressions, but such places can be readily reclaimed by the use of titles. In many cases a single line of tile would be sufficient to remove the excess water.

On some of the steeper slopes the surface soil has been eroded over areas of very small extent. The question of erosion, however, is not a serious one on this type.

Miami loam is derived from the glacial material which covers this entire region, and forms a part of the ground moraine.

The natural growth on the Miami loam consisted of red, white and bur oak, and a few other hardwoods. Most of the type has been cleared and brought under cultivation.

*Agricultural development.** At present the Miami loam is chiefly devoted to general farming. Corn does well and gives a yield of 30 to 50 bushels per acre. A large acreage is devoted to oats each year, yielding on an average 35 to 40 bushels per acre. Rye yields 15 to 25 bushels per acre. Clover and timothy are the important hay crops and do well on Miami loam. Clover alone yields 1½ to 2½ tons per acre, and when mixed with timothy, 1½ to 2 tons. Alfalfa is being grown successfully, but the acreage devoted to it is still small. It ordinarily gives a yield of 2 or 3 tons per acre, and often as high as 4 or 5 tons.

No definite rotation is followed by the majority of farmers, but the following 5 or 6 year rotation was found to be practiced by a number: corn, 1 year; oats, 2 years, or oats 1 year and rye 1 year; clover, 1 year, followed by clover and timothy 1 year; and pasture, 1 year.

No commercial fertilizer is used, but moderate quantities of barnyard manure are applied.

PLAINFIELD LOAM.†

The soil of Plainfield loam consists of a light-brown, medium loam, frequently containing considerable sand and extending to a depth of 8 or 10 inches. The subsoil is a brownish or yellowish clay loam, containing enough sand and fine gravel to give a gritty feel to the material. The content of sand and gravel usually increases below 20 inches, and frequently a gravel

* For information on management and methods for improvement of Miami loam see page 34.

† The soil type here described as Plainfield loam, which contains limestone material in the subsoil, will in the future be classified as Fox loam, and the Plainfield series will be confined to light colored soils occupying outwash plains and terraces where the material is noncalcareous.

bed is encountered at 2 to 3 feet. This gravel shows stratification in places. Most of the pebbles and stones are limestone. Cultivation of this soil is easy, and a loose mellow seed bed can be readily secured.

Though widely distributed the total area of Plainfield loam is small. Several patches are found in the vicinity of Waterville. One small area occurs in the extreme southwest corner of the county, another southwest from Mukwonago, one at Chamberlain, and several northeast of Vernon Station.

A level to slightly undulating surface is characteristic of this soil. On account of the underlying sand and gravel, the natural drainage is good. Where gravel comes close to the surface, crops may suffer from drought.

The material composing the soil consists of glacial dëbris, which has been largely reworked by streams issuing from beneath the ice sheet and deposited as overwash plains and terraces. The surface soil shows slight acidity according to the litmus test.

The original timber growth consisted chiefly of oak, maple, hickory, and other hardwoods. Practically all of the timber has been removed.

Practically all Plainfield loam is under cultivation. It is devoted chiefly to general farming, and is fairly well suited to this type of agriculture. In crop adaptation, methods of cultivation followed, rotations practiced, and yields obtained it compares very favorably with Miami loam, differing from that type chiefly in its topography, method of deposition, and in the somewhat higher percentage of sand.

The following table gives the average results of mechanical analyses of the soil and subsoil of Plainfield loam:

Mechanical analyses of Plainfield Loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent*	*Per cent.*	*Per cent.*
Soil	0.1	2.3	8.2	22.9	12 7	37 6	16.1
Subsoil	.6	4.9	10.3	15.7	9.9	20.7	28.7

METHODS OF IMPROVEMENT FOR MIAMI LOAM AND PLAINFIELD LOAM

These two types of soils, while differing somewhat in method of formation and topography, are quite similar in chemical composition and in crop adaptation. They have on the average about 800 pounds of phosphorus per acre in the surface 8 inches, 35,000 pounds of potassium, and 2,000 pounds of nitrogen. In organic matter they are somewhat lower than the heavier silt loam soils, since the lighter texture permits a more rapid decomposition of the organic matter, and hence tends to lessen its accumulation. These soils are also more apt to become acid than the heavier soils on account of the fact that they are more readily leached. The subsoils, as a result, have very much less lime carbonate than is found in the heavier soils.

The Miami and Plainfield loam types are light colored and deficient in organic matter. The supply of humus-forming material may be increased by supplementing the stable manure with green manuring crops.

An acid condition is found in the surface soil over portions of these types, though it is seldom sufficient to interfere with the ordinary farm crops. Ground limestone should be applied wherever an acid condition exists, to the amount of 1,200 to 1,500 pounds per acre.

It is important to give these types thorough cultivation, though they are not so difficult to handle as the clay loam and silt loam types. The question of selecting the most suitable crop rotations should be given careful consideration, and only such systems followed as will tend to increase the productivity of the soil. Corn one year, followed by a small grain crop one or two years, and then seeding to clover, is a rotation which gives good results. Where the acidity is corrected, and the soil inoculated, alfalfa can be grown, and this crop should be more commonly raised and introduced into the crop rotation.

WAUKESHA LOAM

Description. Waukesha loam consists of a dark-brown, to black loam or silty loam, 8 to 14 inches deep, underlain by a brownish clay loam. Gravel beds are encountered at a depth

of 18 to 24 inches. A quantity of limestone material is present in these beds, which often show stratification. The relatively high percentage of organic matter gives the soil the dark color so characteristic of this type. Most of the soil is acid, according to the litmus test and the abundant growth of sorrel. The phase of Waukesha loam in the vicinity of Mukwonago is rather light in color and texture. The surface soil contains quite a quantity of medium sand, giving it the appearance of a sandy loam. Gravel is usually encountered at 18 inches. One mile south of Eagle the soil is a medium loam and gravel is not encountered nearer than 2 to 3 feet of the surface. On the remainder of the outwash terrace, the soil contains more sand and the gravel is closer to the surface, cropping out in many places. In section 1, Township of Eagle, the Waukesha loam is very light in color, the area being a gradation zone lying next to Miami loam. In the vicinity of Waukesha this type is a true loam. The gravel is here ordinarily encountered at depths of 12 to 24 inches, and often comes as close to the surface as 8 inches. The same may be said of the area south of Oconomowoc, except that the gravel is not encountered above 18 inches. In the vicinity of Beaver Lake, in the southwestern part of the county, Waukesha loam is light in texture.

This soil is not difficult to till, but the plow has to be kept well cleaned and polished, otherwise it will not scour readily. On the heavier phase small cracks and checks are frequently seen.

The largest area is found in Eagle Township. Other areas, though smaller, occur in Waukesha, Mukwonago, and Genesee Townships.

The type occupies a flat to gently undulating topography. The proximity of gravel to the surface establishes thorough drainage, and the soil is somewhat droughty, though during normal seasons good crops are obtained.

The type is derived from glacial material reworked by streams issuing from beneath the ice sheet and deposited as overwash plains. A portion of the type occupies terrace formations. The surface soil is acid and supports a growth of sorrel in many places.

Waukesha loam is largely a prairie type, and while there was a scattering growth of trees over a portion of the region,

the most extensive vegetation was a heavy growth of grass. The growth and decay of this in the presence of excessive moisture accounts for the large supply of organic matter and the dark color.

*Agricultural development.** Waukesha loam is devoted to general farming, corn, oats, and rye being the chief grain crops. The soil is well adapted to corn, and a large acreage is devoted to it each year, yielding on the average 45 bushels per acre, though as much as 65 bushels has been obtained in wet seasons. Oats yield 35 to 40 bushels per acre. Rye is chiefly grown on the lighter phase and is a rather important crop on this part of the type. It yields 15 to 25 bushels per acre. On account, it is believed, of an acid condition of the soil, some difficulty has been experienced in getting a good stand of clover. The average yield is 1 ton to 2 tons per acre. When mixed with timothy the yield is somewhat less. Experimental plot tests carried on by the State Experiment Station show that the application of manure and lime are essential to secure a good stand of clover or alfalfa. Clover should occur more often in the rotation in order to keep up the fertility of the soil.

In the vicinity of Waukesha some cabbage, onions, and carrots are grown, but trucking has not been developed to any great extent.

The rotation most commonly followed on this soil consists of two years corn, two years oats or one year oats and one year rye, one year clover, followed by one year pasture, returning to corn. Manure is applied liberally on the farms of this type of soil.

CARRINGTON LOAM.

Description. The surface soil of Carrington loam consists of a dark-brown or black loam or heavy sandy loam, 8 to 14 inches deep. This rests on a light-brown sandy loam, containing a small quantity of fine gravel. On knolls the soil is only 6 to 8 inches deep, and gravel is encountered at 18 inches or 2 feet. In depressions the soil is darker in color, on account of

* For methods of improvement and management of Waukesha loam, see page 38.

the higher organic matter content,—the subsoil is heavier and gravel content lower. This type differs from Waukesha loam in having a somewhat lighter texture and in not being underlain by a continuous gravel bed. Litmus tests show the soil to be acid, and an abundant growth of sorrel also indicates this condition.

Carrington loam can be cultivated under a wide range of moisture conditions, being very loose and easy to handle. In dry seasons it is not retentive enough of moisture to withstand the drought as long as the heavier soils of the same series.

This type occupies a single small tract in the extreme southern part of the county, about 1½ miles southwest of Big Bend. It also occurs in the western part of Racine County, where it occupies limited areas.

The surface of the type is gently rolling to moderately rolling, and the natural drainage is good.

The type is derived from glacial material, but is not overwash material, as is the case with Waukesha loam, which it somewhat resembles in texture. The dark color is due to a growth and decay of grasses in the presence of moisture.

The original timber growth consisted chiefly of oak and hickory, with a small proportion of other hardwoods. This type and Carrington clay loam may have been prairie land at one time, but as drainage conditions improved, the timber seems to have encroached upon these prairies, which were very limited in extent.

Agricultural development. Carrington loam is devoted to general farming and trucking. Considerable sweet corn is grown, the average yield being about 8,000 ears per acre. It is planted at different times in the spring in order to lengthen the marketing season. Most of it is hauled by wagon to Milwaukee, bringing an average gross return of $60 per acre, though in wet seasons higher returns have been obtained. Melons are also grown to some extent and do fairly well, the gross returns amounting to $200 or $300 per acre. Carrington loam is also a desirable soil for general farming. Corn does well. Wisconsin No. 7 yields on the average 45 to 50 bushels per acre. At present very little oats or barley is grown. Mammoth clo-

ver, which is a very hardy and a coarse grower, yields 2 to 3 tons per acre. Alfalfa seems to do well with proper culture, yielding about 3½ tons per acre.

At present a three-year rotation is practiced to some extent on Carrington loam, consisting of two years of sweet corn and one year of clover cut for hay. Field corn often takes the place of sweet corn in the rotation. Manure is applied liberally to this soil about every three years, but no commercial fertilizers have been used.

METHODS OF IMPROVEMENT FOR WAUKESHA LOAM AND CARRINGTON LOAM

While these two soils differ in topography, the Waukesha loam being essentially on a level or plain and the Carrington loam being more or less rolling, they are very similar in chemical composition. All determinations so far made indicate a higher total amount of phosphorus as well as organic matter, including nitrogen, than is contained in the lighter colored loam soils. The average content of phosphorus is approximately 1,200 pounds per acre in the surface 8 inches; of potassium 32,000 pounds; of nitrogen 4,500 pounds; and the total amount of organic matter is somewhat more than twice as great as that contained in the Miami and Plainfield loams. This larger content of organic matter has given these soils a greater degree of fertility, but it must be borne in mind that a number of years of continuous cropping, without returning manure or other vegetable matter to the soil, will lead to a great reduction in the available plant food. Even though the soil still retains a considerable amount of organic matter, this is in a resistant form, and while it gives the soil a good physical condition and good water holding capacity, it does not mean a high degree of fertility, and steps must be taken to increase the active organic matter. The supply of stable manure may well be supplemented by plowing, under legumes. Under unfavorable treatment phosphorus, even though existing in fairly abundant quantities, will remain in the soil, protected largely by inert organic matter, and so will be unavailable to crops. With reference to acidity and content of lime carbonate, these soils vary, but as a

rule the surface soil is acid, often very distinctly so, and the use of lime will be necessary to permit the best growth of clover or alfalfa on essentially all of the Waukesha and Carrington loams. Ground limestone should be applied at the rate of from 1,200 to 2,000 pounds per acre.

It is important to give these soils thorough cultivation, though they are not so difficult to handle as the clay loam and silt loam types. The question of selecting the most suitable crop rotations should be given careful consideration, and only such systems followed as will tend to increase the productivity of the soil. Corn, followed by a small grain crop for one or two years, and then seeding to clover, is a rotation which gives fairly good results. Where the acidity is corrected, and the soil inoculated, alfalfa can be grown successfully, and this crop should be more commonly raised and introduced into the rotation. The raising of truck crops such as cabbage, sweetcorn, etc., could be profitably extended.

CHAPTER IV.

GROUP OF GRAVELLY AND FINE SANDY LOAM SOILS

MIAMI GRAVELLY SANDY LOAM

Description. Miami gravelly sandy loam, as found in Waukesha County, is a variable type. The greater part of it occurs in two distinct phases. The most extensive and important of these has a light-brown sandy loam to loam, 8 to 10 inches deep, underlain by a reddish-brown gravelly sandy loam, containing enough clay to produce coherence in the soil particles. At 18 inches the gravel content increases, and a considerable quantity of cobblestones and bowlders, mostly of limestone material, are found. Very often the subsoil consists of a gravel bed. Throughout the type occur patches of sand and gravel too small to be shown on the soil map.

A heavier phase consists of an ashen-gray to brown silty loam 6 to 10 inches deep, underlain by a yellowish-brown gritty clay loam to a depth of 18 inches, where gravelly clay loam containing a quantity of cobblestones is encountered. Much of this phase is also underlain by gravel beds. A number of small patches of silt loam are found, but these were too small to be mapped. In both phases a sprinkling of gravel and some bowlders are found upon the surface, especially on knolls, ridges, and around the edges of kettle holes.

This type can be cultivated under a wide range of moisture conditions, and it is very easy to obtain a loose, mellow seed bed. Some difficulty is experienced in cultivating where the gravel is too close to the surface, or where bowlders interfere and the topography is too rough and broken. The gravelly nature of the subsoil makes this type somewhat unretentive of moisture, but in a normal season fair crops are raised, especially on the heavier phase.

Extent and distribution. Miami gravelly sandy loam is found in practically all parts of the county outside of a narrow strip along the eastern side of the area. The heavier phase occurs in the northern half of the county, closely associated with Miami silt loam, and the lighter phase in the southern half, closely associated with the other types of the Miami series. The best developed areas are found in the southern half and western part of the county. In the vicinity of Waukesha Beach and Lakeside Station occur numerous small areas occupying tops of hills.

Topography and drainage. Miami gravelly sandy loam has a rolling, hummocky topography. It occurs on the tops of hills and knolls, and as narrow ridges. Kettle holes abound throughout this type. Dainage is rapid and thorough. From 10 to 15 per cent. of the area is subject to erosion, though it is severe in only a few places. On steep hillsides cover crops should be grown as much as possible. The silty phase is more subject to erosion than the lighter phase.

Origin. The type is derived from glacial debris, a large part of which consists of morainic material forming portions of the Kettle Moraine.

Native vegetation. The original timber growth consisted of white and red oak, hickory, and other hardwoods.

*Agricultural development.** Miami gravelly sandy loam is devoted to general farming. It is fairly well adapted to corn, of which yields of 25 to 40 bushels per acre are secured. Oats and rye are the predominating small-grain crops. A large acreage is devoted to oats, yielding on the average 30 to 40 bushels per acre. Rye averages 15 to 25 bushels per acre. Considerable quantities of corn are grown for ensilage, yielding 8 to 12 tons per acre. Good drainage and the high lime content make it a very favorable soil for clover and alfalfa. Clover is usually seeded with a nurse crop and, as a rule, alfalfa also. The former gives a yield of 1½ to 2 tons per acre, and alfalfa 3 to 4 tons per acre. A larger acreage of alfalfa was found upon Miami gravelly sandy loam than upon any of the other

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* For methods of improvement and management of Miami gravelly sandy loam, see page 45.

soils of the county. On the more gravelly phases the crop yields are less than those stated above.

Up to the present time no commercial fertilizers have been used on this soil; but where it is best developed, manure has been applied at the rate of 6 tons per acre about every four years. The rotation most commonly followed is corn, oats, and rye for one year each, clover for two years, followed by one year of pasture.

The following table gives the average results of mechanical analyses of the soil and subsoil of Miami gravelly sandy loams.

Mechanical analysis of Miami gravelly sandy loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent*	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*
Soil.................	0.9	13.5	18.4	25.4	5.5	25.9	9.9
Subsoil.............	4.1	14.8	18.3	23.6	6.4	13.4	19.0

MIAMI FINE SANDY LOAM

Miami fine sandy loam consists of a brown fine sandy loam to light loam, 8 to 10 inches deep, underlain by a yellow-. amounts of fine gavel. The areas associated with the Kettle Moraine are light in texture, approaching a fine sand in places. Some areas of loamy fine sand were found, but these variations were not of sufficient importance to be separated.

This type is very easy to cultivate and can be worked under a wide range of moisture conditions. The soil is deficient in organic matter and is slightly acid in places, as indicated by the litmus test and growth of sorrel.

Miami fine sandy loam is of limited extent, occupying only a few square miles. The largest area lies $2\frac{1}{2}$ miles northwest of Mukwonago, while a few small patches are scattered about over the southern part of the county.

The surface of the type is gently rolling to rolling, and on account of this and the sandy nature of the soil, the natural drainage conditions are good. Dry weather does not seem to injure crops on this soil as quickly as on some of the heavier types.

The material composing the soil is largely glacial dëbris from the ground moraine, though a few areas occur within the Kettle Moraine.

The original timber growth consisted chiefly of bur and white oak, with a scattering of other hardwoods. At present hazel brush is quite abundant on uncleared areas.

Miami fine sandy loam* is devoted chiefly to general farming, though a small amount of trucking is also done. Corn is grown extensively. It yields from 25 to 40 bushels per acre. Rye gives fair returns, even under adverse conditions, yielding from 15 to 25 bushels per acre. Oats will average 30 bushels per acre. Clover and timothy do fairly well, averaging 1½ tons of hay per acre, though some difficulty is experienced in getting a good stand of clover. At present only a small amount of potatoes are grown, mainly for home use. They yield from 75 to 125 bushels per acre. Barley does not do well, but winter wheat gives fair returns, yielding during the season of 1910 an average of 25 bushels per acre. This, however, is above the yield obtained in most years.

A rotation commonly followed is corn, oats, rye, clover, and pasture, through no definite system is practiced by the majority of farmers. There is less dairying on this soil than on some of the other types in the county, and as a result it receives less manure.

PLAINFIELD FINE SANDY LOAM

The surface soil of Plainfield fine sandy loam consists of a yellowish or brownish fine sandy loam, 8 to 10 inches deep, underlain by a light-colored subsoil of the same texture. In places the material approaches a fine sand, but such variations were too inextensive to be indicated on the map. The surface soil is very low in organic matter and in a number of places slightly acid.

Most of Plainfield fine sandy loam occurs in the western part of the area, the greater part west of the Kettle Moraine in Summit and Ottawa Townships. There is one small area near Chamberlain and two others north of Vernon.

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* For methods of improvement for this type, see page 45.

soils of the county. On the more gravelly phases the crop yields are less than those stated above.

Up to the present time no commercial fertilizers have been used on this soil; but where it is best developed, manure has been applied at the rate of 6 tons per acre about every four years. The rotation most commonly followed is corn, oats, and rye for one year each, clover for two years, followed by one year of pasture.

The following table gives the average results of mechanical analyses of the soil and subsoil of Miami gravelly sandy loams.

Mechanical analysis of Miami gravelly sandy loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent*	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0.9	13.5	18.4	25.4	5.5	25.9	9.9
Subsoil	4.1	14.8	18.3	23.6	6.4	13.4	19.0

MIAMI FINE SANDY LOAM

Miami fine sandy loam consists of a brown fine sandy loam to light loam, 8 to 10 inches deep, underlain by a yellow-amounts of fine gavel. The areas associated with the Kettle Moraine are light in texture, approaching a fine sand in places. Some areas of loamy fine sand were found, but these variations were not of sufficient importance to be separated.

This type is very easy to cultivate and can be worked under a wide range of moisture conditions. The soil is deficient in organic matter and is slightly acid in places, as indicated by the litmus test and growth of sorrel.

Miami fine sandy loam is of limited extent, occupying only a few square miles. The largest area lies 2½ miles northwest of Mukwonago, while a few small patches are scattered about over the southern part of the county.

The surface of the type is gently rolling to rolling, and on account of this and the sandy nature of the soil, the natural drainage conditions are good. Dry weather does not seem to injure crops on this soil as quickly as on some of the heavier types.

The material composing the soil is largely glacial dëbris from the ground moraine, though a few areas occur within the Kettle Moraine.

The original timber growth consisted chiefly of bur and white oak, with a scattering of other hardwoods. At present hazel brush is quite abundant on uncleared areas.

Miami fine sandy loam* is devoted chiefly to general farming, though a small amount of trucking is also done. Corn is grown extensively. It yields from 25 to 40 bushels per acre. Rye gives fair returns, even under adverse conditions, yielding from 15 to 25 bushels per acre. Oats will average 30 bushels per acre. Clover and timothy do fairly well, averaging 1½ tons of hay per acre, though some difficulty is experienced in getting a good stand of clover. At present only a small amount of potatoes are grown, mainly for home use. They yield from 75 to 125 bushels per acre. Barley does not do well, but winter wheat gives fair returns, yielding during the season of 1910 an average of 25 bushels per acre. This, however, is above the yield obtained in most years.

A rotation commonly followed is corn, oats, rye, clover, and pasture, through no definite system is practiced by the majority of farmers. There is less dairying on this soil than on some of the other types in the county, and as a result it receives less manure.

PLAINFIELD FINE SANDY LOAM

The surface soil of Plainfield fine sandy loam consists of a yellowish or brownish fine sandy loam, 8 to 10 inches deep, underlain by a light-colored subsoil of the same texture. In places the material approaches a fine sand, but such variations were too inextensive to be indicated on the map. The surface soil is very low in organic matter and in a number of places slightly acid.

Most of Plainfield fine sandy loam occurs in the western part of the area, the greater part west of the Kettle Moraine in Summit and Ottawa Townships. There is one small area near Chamberlain and two others north of Vernon.

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* For methods of improvement for this type, see page 45.

In topography the surface is level to gently undulating, and the natural drainage is good.

The original growth on this type consisted chiefly of oak, hickory, and a few other varieties. Practically all of the timber has been removed, and the type put under cultivation.

The material composing the type consists of glacial dĕbris which has been reworked by streams issuing from beneath the ice and deposited in the form of overwash plains.

Plainfield fine sandy loam* is devoted largely to general farming, though some trucking is also carried on. The ordinany farm crops yield practically the same as on Miami fine sandy loam. In addition to these sorghum is sometimes grown, yielding about 50 gallons of sirup per acre. An excellent quality of potatoes can also be produced, but at present only a few are grown. In the vicinity of Dousman strawberries of fine quality are being grown. The ordinary gross returns from this crop average from $250 to $300 an acre. Often as much as $500 an acre is obtained. Most of the berries are shipped to Milwaukee, where they bring the same prices as Michigan berries.

Since this type is located in a section where there is but little dairying, it does not receive as much stable manure as some of the other soils.

WAUKESHA GRAVELLY LOAM

Waukesha gravelly loam consists of a reddish-brown or black loam, 8 to 10 inches deep, resting upon a reddish brown, sticky gravelly sandy loam. Enough clay is present in this material to make the particles cohere. At 22 inches a light-yellow sandy gravel, including a quantity of large cobblestones, is encountered. Stratified beds contain a quantity of limestone material. The dark color is due to the large percentage of iron and organic matter present. On knolls the soil is very shallow and gravelly; in depressions and on small flats it is deeper, and the gravel not so close to the surface. Many small patches of this type, too small to map, were found

* For methods of improvement for this type, see page 45.

in Waukesha loam areas, especially in the vicinity of North Prairie.

As a whole, this soil is very easily tilled, except on the knolls, where the presence of gravel interferes with cultivation. The open and porous subsoil makes the type rather droughty.

Waukesha gravelly loam is of limited extent occupying chiefly the upper terraces of the Eagle Prairie, northeast of Eagle.

The surface of the type is gently rolling to rolling, and the natural drainage is excessive. Crops suffer from drought dur-almost every growing season. The more rolling portions could be classed as Carrington gravelly loam, if of sufficient extent.

Waukesha gravelly loam is of glacial origin and consists of morainic material, some of which has been reworked and assorted by the action of water.

The original timber growth consisted chiefly of bur and white cak. A portion of the type is still in timber.

Waukesha gravelly loam is devoted to general farm crops. Corn yields 15 to 35 bushels per acre, with an average of 20 bushels per acre, with an average of 20 bushels. Rye and oats are the most important small-grain crops. Oats yield 25 to 35 bushels, and rye 15 to 25 bushels per acre. In dry seasons difficulty is experienced in getting a good stand of clover, but in wet seasons a good catch is usually obtained. Clover yields $1\frac{1}{2}$ tons, and when mixed with timothy, three-fourths ton to $1\frac{1}{4}$ tons per acre. Manure has been used liberally on this type but no commercial fertilizer. The general rotation practiced is as follows: Corn, oats, rye, clover, followed by one year pasture, after which the land is plowed again for corn. As a rule the land receives an application of manure before planted to corn.

METHODS OF IMPROVEMENT FOR MIAMI GRAVELLY SANDY LOAM, MIAMI FINE SANDY LOAM, PLAINFIELD FINE SANDY LOAM, AND WAUKESHA GRAVELLY LOAM

While differing in topography, these soils are quite similar in chemical composition and in most conditions which affect fertility. They show a fair amount of total prosphorus, which averages approximately 1,000 pounds in the surface 8 inches of an acre, though Waukesha gravelly loam runs considerably

above this average, and Plainfield fine sandy loam somewhat below it. Their total content of potassium is moderate, varying from 25,000 to 35,000 pounds to the acre. Their content of nitrogen, however, is rather low, especially in Plainfield fine sandy loam, which has approximately 1,300 pounds per acre. Miami fine sandy loam and Miami gravelly sandy loam have about 2,000 pounds per acre 8 inches. Waukesha gravelly loam runs much higher, averaging nearly 4,900 pounds.

The total organic matter is found in about the same ratio. It is evident, therefore, that all of these soils, with the exception of Waukesha gravelly loam, stand in marked need of the addition of organic matter. Not only is this essential for a good supply of nitrogen and to increase the water-holding capacity of these soils, but its decomposition is necessary to render available the mineral elements phosphorus and potassium.

Even in Waukesha gravelly loam much of the organic matter, especially of fields which have been cropped for a number of years without barnyard manure or green manure, is of such inert character, that it is of relatively little value in causing the decomposition of the mineral bases of the soil.

The lime content of these soils was originally high, the coarser particles being made up of limestone. The surface soils have, however, been to a considerable extent leached, so that they are usually acid, even though the subsoil frequently contains the larger part of its original supply of limestone. Each farmer should, therefore, test for acidity on his own fields, to determine the need of lime, especially for the growth of clover and alfalfa.

To increase the organic matter and improve the waterholding capacity, green manuring crops may be used to supplement the stable manure. Where an acid condition exists in the surface, ground limestone should be applied. On the steeper slopes the surface should be kept covered with a growing crop as much of the time as possible, or permanent pastures may be established in such places. Intertilled crops should not be grown on the steep slopes.

Miami gravelly sandy loam is well adapted to alfalfa, especially the heavy phase, and this crop should be grown more

extensively. It not only supplies a large quantity of highly nutritious feed, but it probably produces a larger quantity of organic matter and nitrogen for the farm as a whole, than could be produced on an equal acreage of any of the other soil types in this region. On the fine sandy loam types the trucking industry could well be developed to a much greater extent, as these soils are well suited to early truck crops and located conveniently for shipping and marketing.

CHAPTER V.

GROUP OF SAND SOILS

MIAMI SAND *

Miami sand consists of a yellowish to brownish-gray, medium to fine sand 6 to 8 inches deep, underlain by a loose, incoherent yellow sand of the same texture. The soil is very low in organic matter. Because of its loose, open structure, it is easy to cultivate and can be worked under almost all moisture conditions. When the surface is not covered by a crop, the sand is sometimes blown by the wind, though not to any marked extent.

Areas of Miami sand are confined to the southwest part of the county, where they are associated with the Kettle Moraine. The type is of small extent and not highly improved.

The surface is gently rolling to rolling, which, with the loose, open character of the soil and subsoil, makes the drainage too thorough, the crops suffering from drought, except when the rainfall is unusually well distributed.

The type is of glacial origin and consists partly of morainic material.

Bur oak, red oak, and white oak, of rather scrubby growth, were the original timber growth. At present hazel brush covers a part of the type.

The greater part of it is under cultivation, the chief crops being corn, oats, rye, and clover. When the rainfall is well distributed, fair yields are obtained. But there is usually a dry period of considerable length during each season, and all crops on this soil suffer. The land is not highly developed.†

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* The soil here described as Miami sand contains no limestone in soil or subsoil and in the future such soil will be classed as Coloma sand.

† For methods of improvement for Miami sand, see page 50.

PLAINFIELD SAND

Plainfield sand consists of a brown, medium to fine sand, extending to a depth of 6 to 8 inches, underlain by loose, incoherent, yellow to reddish-brown sand of medium texture. In the areas associated with the large marsh west of Eagle, the soil contains considerable organic matter, which gives the loamy character. In some of these areas the deep subsoil grades into a sticky sand. Such spots approach a sandy loam, but on account of their limited extent they were not mapped separately.

On account of the loose, open structure of Plainfield sand it is easy to cultivate and can be worked under a wide range of moisture conditions. According to the litmus test, the soil is usually more or less acid. This condition was further indicated by a growth of sorrel.

Plainfield sand is confined chiefly to the southwestern part of the county west of the Kettle Moraine, though there are a few patches east of the moraine in the southern part of the survey. Much of the type consists of islands in the large marshes, and in places it forms a border along the swampy areas.

The surface of the type is level, but owing to its sandy open nature the drainage is good. It does not suffer from drought as much as upland soils of same texture, as the water table is nearer the surface.

Plainfield sand consists of glacial material, which has been largely reworked and deposited as outwash plains by glacial streams.

The original timber growth consisted chiefly of scrubby bur, red, and white oak. Hazel brush is quite plentiful at the present time.

Areas of Plainfield sand are devoted to general farming and trucking, and, as a rule, fair crops are produced. Corn yields from 15 to 35 bushels per acre. The oat crop is not very satisfactory; only enough for feeding the work stock is produced. From 20 to 25 bushels per acre is the usual yield. Quite a large acreage is given to rye, the average production being 20 bushels per acre. The growing of barley is not a suc-

cess, and the acreage is small. It is sometimes difficult to get a stand of clover, especially in dry seasons, unless the soil has been carefully farmed. A small amount of sorghum is grown for making sirup. Cucumbers and potatoes are grown with success, as are also melons and strawberries.

METHODS FOR IMPROVEMENT OF MIAMI SAND AND PLAINFIELD SAND

As is generally true with sandy soils, these two types are low in their total content of all the essential elements. The total amount of phosphorus in the surface 8 inches per acre is between 500 and 600 pounds; of potassium between 20,000 and 25,000, and of nitrogen approximately 1,300. There is practically no lime carbonate in the soil to a depth of 3 feet, except that which is in the form of coarse sand and gravel, and hence of relatively little influence in preventing the development of acidity in the soil. It is evident, therefore, that the maintenance of any considerable degree of fertility in these two types of soil will require the use of methods for increasing the nitrogen and organic matter by applying stable manure, peat, or by the growth of legumes, or green manuring. For the growth of these legumes, as for other crops, available plant food containing both phosphorus and potassium must be used. By neutralizing the acidity with ground limestone, and by the use of moderate amounts of fertilizers containing phosphorus and potassium, good crops of legumes such as clover or the annual legumes—cowpeas, soybeans, and yellow lupines—may be grown so as to greatly increase the organic matter. When a good supply of active organic matter has thus been developed, the need for application of potash fertilizer will largely disappear, though the need of some phosphate will continue unless the system of farming is such as to return practically all of the phosphorus containing substances to the soil. Since this is not practicable in the growing of truck crops to which these lands are especially adapted, their most profitable use will be in connection with the use of phosphate fertilizers as well as the growing of legumes. Potatoes, strawberries, cucumbers, melons, tomatoes, and the like, could well be grown on these soils to a much greater extent than they are at present.

CHAPTER VI.

GROUP OF POORLY DRAINED SOILS

CLYDE SILTY CLAY LOAM.

Description. Clyde silty clay loam consists of a dark-brown or black silty clay loam, 6 to 10 inches deep, underlain by a drab or bluish clay to a depth of 24 inches, where a bluish or sometimes mottled, plastic, silty clay is encountered. The mottled subsoil is very impervious and puttylike and contains iron stains and some calcareous material. Along streams and small depressions the soil is from 10 to 12 inches deep, lighter in texture, and usually modified by some coarse sand and gravel in the lower subsoil. A high percentage of organic matter gives this soil its characteristic dark color. When the amount of organic matter was sufficiently large and the mineral matter low, the material was mapped as peat. According to the litmus test, Clyde silty clay loam is neutral.

Extent and distribution. The chief occurrence of this type is in the eastern tier of townships. Numerous other areas are found around Muskego, Big Bend, Elm Grove, Brookfield, and Menomonee Falls. Besides these there are other areas distributed throughout the county. Many patches too small to map occur in the Miami clay loam, silt loam, and loam types. The heavier phase of this soil is closely associated with Miami clay loam.

Topography and drainage. Clyde silty clay loam occupies level areas. The drainage is poor. Variations are due largely to the different degrees of drainage possessed by this soil. In the better drained areas, and also where there has been a large accumulation of organic matter, the soil becomes loamy and very friable, while in the poorly drained areas the surface soil has the appearance of a clay. A single open ditch extending

across an area with tiles leading into it at intervals of 4 rods would in nearly all cases give adequate drainage. The size of ditch should vary with the size of the area to be drained, amount of upland draining into the basin, and the fall. Narrow strips along streams, subject to overflow, will be rather difficult and expensive to reclaim.

Origin. This soil has been derived from glacial material occupying old lake beds, the lowland along streams, and small depressions. In such places a large quantity of organic matter has accumulated and become mixed with the mineral constituents of the soil.

Native vegetation. The original timber growth consisted chiefly of elm with a few oaks and some willows in the wettest places. Much of the type is still in timber.

*Agricultural development.** Up to the present time very few areas of Clyde silty clay loam have been reclaimed. Part of the tract immediately north of New Berlin, and a few small patches around Muskego Lake have been put under cultivation. A tile factory about 2 miles north of Denoon has made it very easy to obtain tile for that district. Where the type is not drained, some of it is used for hay and pasture. When Clyde silty clay loam is drained, it becomes very loamy and mellow under cultivation. It can not be worked under as wide a range of moisture conditions as Clyde loam, but it is not very difficult to handle. If cultivated too met, the soil is apt to puddle, and large clods, which are difficult to pulverize, ae sometimes formed. Checks and cracks an inch in width are commonly found, but by proper cultivation these can be prevented in fields occupied by intertilled crops. This type has never been known to suffer from drought. During dry seasons crops do well on undrained land. In wet seasons conditions are not favorable for the growth of crops, except where artificial drainage has been established.

On the drained areas of Clyde silty clay loam, general farming and some trucking are carried on. The soil is well adapted to corn, and most of the reclaimed land is devoted to

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* For methods of improvement for this type see page 55.

this crop. It gives an average yield of 40 bushels per acre, with a maximum yield of 70 bushels. Oats do fairly well, but, as a rule, lodge before ripening. Heavy crops of potatoes are obtained, yields of 300 bushels per acre being common. The average is about 150 bushels per acre. As on Clyde loam, the tubers are inferior in quality, often being too large and hollow. Most of the crop is consumed at home. Some are marketed in Milwaukee. This type is well adapted to the wild grasses and, when drained, to timothy and redtop. The grasses ordinarily yield 1½ to 2½ tons of hay per acre.

In the vicinity of Menomonee Falls, a few small, drained areas are devoted to the cultivation of sugar beets. Beets grow luxuriantly on this type, yielding from 15 to 18 tons per acre. The sugar content is lower than in case of beets grown on Miami clay loam, but the tonnage is enough greater to make the gross receipts somewhat higher.

In the vicinity of Elm Grove cabbage and cauliflower are grown on a few drained tracts. Cabbage yields 10 to 18 tons per acre, and the average returns from cauliflower are $150 to $180 an acre.

In Racine County, in the vicinity of Racine, this type has become a great trucking soil. Cabbage produces 10 to 15 tons per acre, onions 400 to 700 bushels, and potatoes 150 to 250 bushels per acre. No commercial fertilizers have been used, and manure has been applied only sparingly.

CLYDE LOAM.

Description. The surface soil of Clyde loam consists of a dark-brown to black loam, 10 to 14 inches deep. This is underlain by a drab-colored clay loam, which grades into a yellowish or bluish clay at 24 to 30 inches. In the subsoil seams of sand 3 to 4 inches in thickness are very common. The subsoil is mottled and usually streaked with iron stains. It also contains some calcareous material, and gravel is frequently encountered in the third foot. A high percentage of organic matter gives the soil a dark color and makes it very loamy and mellow. In the area east of Mukwonago, the surface soil contains a quantity of medium sand and approaches a sandy loam

in texture. The areas northwest of Eagle and south of Dousman, also, belong to this phase. The subsoil is a mottled, sticky, clayey sand. Another phase is found closely associated with Miami silt loam, usually occupying narrow draws and depressions. It is a dark brown or black loam, approaching a silt loam in texture, 10 to 14 inches and sometimes 18 inches deep. The subsoil consists of a mottled, yellowish-blue clay rather impervious to water. Clyde loam is often the gradation type between Peat and upland soils. Such areas occur as bands, and in some instances these were so narrow that it was not found practicable to map them.

When reclaimed, this type is very easy to handle, and can be cultivated under a rather wide range of moisture conditions. On the heavier phases some checking and cracking occurs, but not enough materially to affect the supply of soil moisture. On such land cultivation should be avoided when the soil is moist.

Clyde loam occurs chiefly in the townships of Mukwonago, Vernon, Waukesha, Genesee, Pewaukee. Other small tracts occur throughout the county.

This type occupies a level topography and is poorly drained. Clyde loam can be readily reclaimed by ditching and tiling, as suggested for the drainage of the silty clay loam type. Since the subsoil is not so impervious as that of the other type, sufficient drainage may be secured by placing the tile drains 6 rods apart.

Areas of Clyde loam occur along streams, in glacial lake beds, and in depressions. It has originated from reworked glacial till in which large amounts of organic matter have accumulated.

The original timber growth consisted chiefly of elm, soft maple, willows, etc. Some timber still remains on the type, and but little has been put under the plow.

Agricultural development. At the present very little of Clyde loam has been reclaimed, though most of it is used for pasturage and hay. When drained it is adapted to trucking and fairly well suited to general farming. No trucking is carried on at present, but this industry should be developed on tracts conveniently located. Corn does well, and most of the re-

claimed areas are devoted to its cultivation, giving ordinary yields of 35 to 60 bushels per acre. Very little oats or rye was seen. These crops grow luxuriantly, but often lodge before the grain is mature. Heavy yields of potatoes have been obtained, ranging from 120 to 150 bushels, with a maximum of 250 bushels per acre. Potatoes grown on Clyde loam are inferior in quality, usually larger than the market demands, and consequently bring a price below the standard market quotations. Wild grasses and bluejoint do well on this type. When thoroughly drained, timothy can be grown successfully. The grasses yield 1½ to 2 tons of hay per acre.

Stable manure is the only fertilizer used on Clyde loam.

METHODS OF IMPROVEMENT FOR CLYDE SILTY CLAY LOAM AND CLYDE LOAM.

Since these soils are formed along the border line between upland light colored soils and peaty and muck marsh soils, they are intermediate in chemical composition between these two extremes. Moreover, their position is such that they have received a considerable deposition of fine silt from the higher land with its larger content of plant food. These soils have in the surface 8 inches approximately 2000 pounds of phosphorus per acre; from 30,000 to 40,000 pounds of potassium; and approximately 10,000 pounds of nitrogen. Since they are surrounded by highland, the subsoils of which are rich in ground limestone which is being continuously dissolved and carried to the lower lands by percolating waters, they are as a rule not acid, and in fact usually contain considerable quantities of lime carbonate.

In spite of their large content of both phosphorus and potassium, it is not infrequently true that these soils show low availability of these elements, especially of potassium. This is probably due to the inert condition of much of the organic matter which protects the earthy part of the soil. Where thoroughly good artificial drainage has been developed and nevertheless poor crops secured, this result will usually be found to be due to lack of available potassium and in some cases also of phosphorus. A direct experiment should be

made in these cases with potassium and phosphate ferilizers, as suggested in he bulletins of the Experiment Station.[1]

The most important question in the improvement and management of these soils is one of drainage. Practically all areas are in need of drainage, and tile drains will be found most practical in the majority of cases. When properly drained and well managed, very satisfactory yields can be secured. Cabbage, onions, and sugar beets are some special crops which can be successfully raised on these soils, aside from the general farm crops, such as timothy, alsike, clover, and corn. Stable manure should not be applied to these soils as the nitrogen is not needed. The mineral elements, where needed, may be supplied in the form of commercial fertilizers, as indicated above.

CLYDE SANDY LOAM.

Description. Clyde sandy loam consists of a dark-brown to black sandy loam, 8 to 10 inches deep, resting upon a brownish-yellow sand or sandy clay. Near Vernon Station the type has a mottled, silty clay subsoil at a depth of 3 feet. West of Mukwonago a mucky phase is found. The soil here consists of a black mucky sand 6 to 8 inches deep, resting on a mottled-yellow sand. At 30 inches a grayish sand is encountered.

The loose loamy character of the soil makes it easy to handle. Its sandy subsoil makes it somewhat droughty during long periods of dry weather. This is especially true of the areas lying adjacent to lowlands which have been thoroughly drained.

Extent and distribution. Clyde sandy loam occurs chiefly in the southern half of the county in small scattered areas, the largest of which are found east of Saylesville, in the vicinity of Vernon, and west of Mukwonago. Besides there are other occurrences of small extent distributed over the southern part of the survey.

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[1] For more information write to Wisconsin Experiment Station for bulletins on drainage and fertilization of low, poorly drained tracts of land.

For special information on drainage, see Bulletin No. 229 of the Wisconsin Experiment Station.

Topography and drainage. This type occupies a position intermediate between Peat and the upland soils; it has a flat to gently undulating topography, and the drainage is fairly good, except on the mucky phase, where the water level is too close to the surface. On the more undulating land the physical character of the soil insures good drainage, whereas on the level tracts ditching and tiling will have to be resorted to in order to make the land tillable. In most cases the large areas of Peat will have to be drained, before the mucky phase of this type can be reclaimed.

Origin. Clyde sandy loam is derived from sandy material deposited in ancient lakes, and, as it has been subjected to a swampy condition for a long period, large amounts of organic matter have accumulated and become incorporated in the soil.

Native vegetation. The chief native growth on this type consisted of hardwoods on the higher portions of the type, and willows, grasses, etc, on the mucky phase.

Agricultural development. At present it is mostly devoted to general farm crops. Corn yields 30 to 50 bushels per acre. Rye and oats give fair yields, but since so little of the type has been reclaimed, very little can be said concerning crop yields. The better drained land receives a dressing of manure occasionally, but no commercial fertilizers are used.

Method of improvement. This type of soil, on account of its sandy nature, contains relatively lower amounts of phosphorus and potassium than do the heavier Clyde soils, the total phosphorus averaging about 1,000 pounds per acre in the upper 8 inches, and the total potassium about 30,000 pounds. The total nitrogen is approximately 6,000 pounds. Soils of this class are quite variable in their content of lime. Their coarser texture permits the leaching of this substance much more rapidly than occurs in the heavier Clyde soils, and small areas are frequently found in which a slight degree of acidity has developed, though for the most part soils of this type are not acid. Their improvement will usually require only the use of commercial fertilizers containing phosphorus and potassium, since in practically all cases there is sufficient nitrogen, and all stable manure should be applied to the upland soils unless there is sufficient manure to use on this soil as well as on the upland portion of the farm. Tile drains or ditches should be

installed wherever drainage is deficient. When drained and properly fertilized, profitable crops can be secured with little difficulty on portions of the type at present unimproved.

The following table gives the average results of mechanical analyses of the soil and subsoil of Clyde sandy loam.

Mechanical analyses of Clyde sandy loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil...............	0.0	12.7	26.3	29.2	3.3	20.7	7.3
Subsoil............	.5	15.1	31.5	38.1	4.5	6.1	4.1

CHAPTER VII

PEAT

(With Included Areas of Muck)

Description. A large number of Peat marshes ranging in size from a few acres to several square miles in extent are scattered throughout the county. These form a characteristic feature of this portion of the State. The material composing such areas consists of vegetable matter in varying stages of decomposition, to which has been added, in some instances, varying amounts of mineral matter by the wash from the adjoining higher lands. Peat refers to the decaying vegetable matter in varying stages of decomposition. It may be raw and fibrous, or well decomposed, but should contain only a small percentage of mineral matter. When there is considerable mineral matter present, the material is Muck. In the soil survey, when the mineral matter content was found to be too high for Muck, and sufficient to impart to the material a loamy or clayey characteristic, it was classed with the Clyde series. On the soil map one color was used for showing the location of highly organic soils, whether Peat or Muck, as it was not practicable to make a separation.

In small marshes, and in narrow strips along streams, there is usually considerably more mineral matter, and the Muck is from 1 to 4 feet deep, while in the large marshes the material is true Peat, and from 5 to 15 feet deep. In some localities the surface is quite thoroughly decomposed while the underlying material is fibrous. Throughout most of the area, a bluish or mottled, stiff, plastic clay is found beneath the marshes, except in the western part of the county in the vicinity of sandy and sandy loam areas, where a sand or sandy clay is encountered. Marl deposits are found under some of the marshes.

Extent and distribution. Large and small marshy areas are scattered throughout the county and associated with practically all of the soil types. Many of the small patches were too small to be indicated on the soil map. The largest area occurs in the southwestern part of the county, extending north from a point 3 miles west of Eagle for nearly 10 miles. Some portions of this tract are raw Peat, but much of it is practically decomposed. The material varies in depth from 2 to 8 feet and is underlain by sand or sandy clay, except in sections 3 and 4, Eagle Township, where a marl bed over 50 feet thick is found. A factory has been established on the edge of the marsh to develop this deposit. Other small occurrences of marl are found throughout this large marsh. The fall is considerable, and practically all of this tract could be drained. No effort has been made to reclaim the whole area, though a project for draining a portion has been undertaken. The second area in size begins 1 mile north of Mukwonago and extends north for about 6 miles along the Fox river. It has a width of 1¾ miles at one point. The material consists of a mucky Peat extending to a depth of 5 to 15 feet, underlain by a blue clay. It would be practically impossible to drain this tract, as the Fox river is sluggish and the fall slight. If the dams which obstruct the river in Racine county ever are removed, this marsh may also be reclaimed. Other marshes of over 2 square miles in extent occur in Menominee, Brookfield, and Muskego townships, while smaller patches are found in all parts of the survey.

Topography and drainage. The topography of all these areas of course is flat, and the natural drainage poor. During the spring and in wet seasons, water stands over much of the surface. Only a very small proportion of the marshes have been reclaimed, though nearly all of these tracts could be successfully drained, and several projects are now being developed. As land values advance, the interest taken in these marshes becomes keener, and the time will doubtless come when the reclaimed Peat will be fully used.

Native vegetation. The natural growth on the marshes consists of wild grasses, willows, and tamarack. Many of the

marshes are entirely open, supporting only a growth of wild grass, and during dry seasons taking on the appearance of prairies. Others have a growth of tamarack in the center of the swamp, with wild grass and willows around the margin, while a few are entirely covered with tamaracks. It is probable that, where the tamaracks exist, the swamps are older than those upon which only wild grasses occur.

Agricultural development. During the dry seasons nearly all of the marsh grass is cut for hay, but if the ground is saturated with water, it will not support the weight of a team. Many of the marshes are divided into small tracts and owned by farmers in the vicinity, who depend upon the marsh for hay when the usual supply from the upland fails, or is short.

A few reclaimed tracts were seen where corn, timothy, and cabbage were being grown successfully.

METHODS OF IMPROVEMENT*

Peat has been largely formed by the accumulation of vegetable matter, particularly sphagnum moss and certain sedges and grasses. It is very low in earthy matter, running from 80 to 95 per cent. of organic matter. The amount of the mineral elements is consequently low, the total weight of phosphorus being approximately 600 pounds per acre to a depth of 8 inches, and of potassium, 700 pounds. It will be seen, on comparison of these statements with those made on the composition of such soils as Miami clay and silt loams, that the total amount of potassium, in particular, is extremely small, the amount in Peat being often less than 2 per cent. of that found in the upland silt and clay loam soils. While the total amount is small, a large proportion of it is available to plants, especially if the surface has been burnt over, and the supply may be sufficient for from 1 to 3 crops. It is to be expected, therefore, that profitable cropping is possible over a long period of years, only by the use of some form of potassium fertilizer, either barnyard manure, word ashes, or the usual commercial fertilizers containing this element. The

* **Wisconsin Experiment Station, Bulletin 205, Management of Marsh Soils.**

total supply of phosphorus is rather low, though the difference between the amounts present in Peat and upland soils is very much less than in the case of potassium. In view of the enormous quantity of nitrogen contained in these soils, the average amount of which is over 15,000 pounds per acre 8 inches, it is unnecessary to use stable manure, the most valuable element of which is the nitrogen, so that, on farms including both Peat or Muck land and upland soils, the stable manure should be used on the upland, and commercial fertilizers containing phosphorus and potash, if needed, on the lower land, unless, indeed, there is sufficient manure for the entire farm, which is rarely the case. These marsh soils are rarely acid on account of the percolation of lime-containing water from higher lands, though occasionally patches of acid Peat are fund on the larger marshes. This acidity, however, is not so detrimental in the case of marsh lands as in the case of sand and clay soils, since the chief objection to acidity is that it interferes with the growth of those legumes, such as clover and alfalfa, which are needed on the higher lands to secure nitrogen, but which are not needed on the marsh soils for this purpose, and to the growth of which, indeed, the marsh soils are not physically so well adapted.

In the improvement of Peat the question of drainage* is the first step to be considered. Both open ditches and tile drains can be utilized in reclaiming the marshy tracts. The major portion of the Peat areas in Waukesha county can be profitably drained and improved. When properly handled the Peat will produce profitable crops of corn, alsike clover, timothy, and a number of other general farm crops, as well as special crops such as peppermint, celery, etc.

* For special information concerning drainage, write the Soils Department of the Wisconsin Experiment Station.

FIG. 3. VIEW OF WAUKESHA LOAM ON PRAIRIE SOUTH OF WAUKESHA. SHOWING LEVEL SURFACE CHARACTERISTIC OF OUTWASH PLAIN REGIONS.

WISCONSIN GEOL. AND NAT. HIST. SURVEY PLATE III.

FIG. 4. VIEW OF MIAMI GRAVEL WEST OF EAGLE. SHOWING TYPICAL ROUGH, BROKEN TOPOGRAPHY AS FOUND IN THE MORAINIC REGION.

This type is not adapted to cultivated crops, but supplies some grazing.

CHAPTER VIII.

MISCELLANEOUS SOILS.

MIAMI GRAVEL.*

The surface soil of Miami gravel consists of a dark-gray to dark-brown sandy loam 6 to 8 inches deep, carrying high percentages of gravel, cobblestones, and bowlders on the surface, and mixed with the finer soil material. The underlying material consists of a heterogeneous mixture of sand, gravel, and bowlders, composed chiefly of limestone. Most of the gravel is water-worn to some extent, and in a few cuts the material shows stratification. The surface soil in the northern part of the county contains a higher percentage of silt than that found in the southern part.

The Miami gravel is confined almost entirely to the western half of the county and is closely associated with the Kettle Moraine.

The type occurs as well-rounded hills and knolls, and as small, narrow, choppy ridges. Kettle holes from 50 to 100 feet deep are abundant. On the tops of hills, knolls, and ridges, the soil has been removed, leaving large bodies of gravel and stone exposed, while in the depressions a good covering of soil is found. The soil is very droughty.

Miami gravel is of glacial origin and consists entirely of morainic material.

The original timber consisted chiefly of scrubby oak. But little of the type has been cleared.

The nature of the material and the topographic position render Miami gravel practically non-agricultural. The land is used largely for pasture, and in the early summer supports a good growth of June grass, but later this fails on account of

*1 In the future soil of this character will be classed as Roman gravel.

drought. Most of Miami gravel should be left in wood-lots, and where it has been cleared it would doubtless be advisable to reforest the land.

MEADOW.

The type Meadow includes narrow strips of low-lying land along streams, where the soil is subject to overflow and quite variable in texture, so that it can not be classified with any of the other established types. Where found along the Menominee River, in the eastern part of the county, the soil consists chiefly of a dark-brown clay loam, underlain by a heavy, compact, yellowish-brown clay, more or less mottled. A lighter phase occurs along the Fox river, north of Waukesha, and along the streams northeast of Merton, south of Mukwonago Lake, and north of Eagle Lake. It consists of a dark-brown to black loam, 8 to 16 inches deep, underlain by a heterogeneous mixture of mottled clay, sand, and gravel. In the latter phase the soil contains a high percentage of organic matter. Shells and iron stains are very common in the subsoil. The type is subject to overflow, and drainage would be difficult and expensive. Meadow makes good pasture and hay land. The native growth consists of wild grasses, reeds, and willows.

CHAPTER IX.

GENERAL AGRICULTURE OF WAUKESHA COUNTY

The early history of agriculture in Waukesha County dates back to 1834, when the first settlement was made on the present site of the city of Waukesha. The Indians who inhabited this region had scratched the soil and grown some corn prior to this time, but their efforts are scarcely worthy of consideration.

The raising of grain early became the leading industry, and for about 15 years, winter wheat was grown. What spring wheat was sown at first did not yield satisfactorily, except on the "openings" and prairies where the winter wheat killed out. Spring wheat came gradually into favor, however, and for a period of about 25 years, or up to 1880, it was grown almost exclusively. About this time, owing to small yields from continued cropping on the same fields, drought, the chinch bug, weevil, and the decline in prices, the acreage of spring wheat was greatly reduced, and winter wheat was again tried. Up to 1878 and 1880 the raising of wheat gradually increased. In 1880 there were 42,038 acres in the area, which gave a yield of 711,839 bushels. Since that time there has been a rapid falling off in the wheat production, and in 1910 there were only 1,177 acres in this crop, which produced 22,706 bushels. The amount grown at present is still smaller, and only a few fields were seen in each community throughout the county.

The growing of hops was at one time an important industry in the area. Up to 1860 only a few were grown, but by 1867 and 1868, the "hop fever" had reached its height. Nearly every farmer went into the business, and some on quite an extensive scale. The hop louse in the East and the increased demand of brewers made hops a very profitable crop. In 1857

the price was from 40 to 50 cents a pound, and in many cases a single crop paid for the land and all improvements. So many went into hop raising, that overproduction resulted. In 1869 the price was 10 to 15 cents a pound, while hops of poor quality brought only 3 cents a pound. The prices went even lower than this. The hop louse also invaded the region, and this, in connection with low prices, aided in bringing failure upon many farmers. By 1880 hop growing was almost entirely abandoned.

During the decline of the hop industry, the production of barley gradually increased. In 1890 the crop of the county from 32,880 acres amounted to 1,174,100 bushels, an average of 37 bushels per acre. By 1910 the acreage had fallen to 11,811, and at present there is only about one-fourth as much grown as there was 25 years ago.

While wheat was grown more extensively than any other grain in the early history of the county, it was not grown to the exclusion of other crops, and as early as 1839 the yield of corn in what is now Waukesha County amounted to 23,063 bushels, that of oats 18,202 bushels, buckwheat 29,008 bushels, and potatoes 36,634 bushels.

The early methods of farming were crude and wasteful. Fields were poorly cultivated; often planted to the same crop, year after year. No thought was given to the question of maintaining or improving the productiveness of the soil, and as a result the yields decreased. When the reduction in yields and the cause thereof became apparent, the system was gradually improved, until at the present time a large number of farmers follow a system of crop rotation, exercise considerable care in the selection of seed, return large amounts of organic matter to the soil in the form of barnyard manure or green crops, and the most up-to-date farmers are constantly on the lookout for methods by which conditions may be still further improved.

About the time of the failure of the hop industry (1879) the growth of the factory system of butter and cheese making began, and the type of agriculture now practiced throughout the area consists chiefly of dairying in conjunction with gen-

eral farming and stock raising. Dairying is the most important branch of farming in Waukesha county, and the magnitude of this industry can be appreciated when it is known that in 1905 the production of milk was 115,184,390 pounds, having a value of $1,211,216. A large proportion of this was made into butter, some into cheese, and a large amount was shipped to Milwaukee and some to Chicago. The state census of 1905 states that at that time there were, within the area, 35 creameries and 5 cheese factories, which received 52,803,337 pounds of milk that year.

In 1910 there were 7 cheese factories and 27 creameries. From 1905 to 1910 the yearly output of cheese from the county nearly doubled, but during the same time there was a marked decrease in the amount of butter produced. The reason for this decrease is that, although the number of milch cows increased considerably, the amount of whole milk shipped to Chicago and Milwaukee has increased in still greater proportion. Then, too, some who formerly sent milk to a creamery are now patronizing cheese factories.

The census of 1905 states that at that time there were 27,648 milch cows in the county. In 1910 there were 31,983. While the greater proportion of the dairy herds are grade stock, there are many pure-bred herds, and the number of these is increasing gradually. Where the object is the production of a large quantity without regard to the butter-fat content, pure-bred or grade Holsteins are the most desirable, and those who ship to the regular trade in Milwaukee, or to cheese factories, usually prefer this breed. Many of those who patronize a creamery or ship the milk to consumers; who wish a rich, well-colored-product, prefer the Guernsey or Jersey; the latter, however, are not held in very high favor in this region, and there are comparatively few in the county.

There are more Holsteins in the county than pure breds of any other class. They are noted especially for the quantity of milk they produce. Their calves are large, and, if desired for veal, they will bring in more money than calves of smaller breeds. The Guernsey has in recent years come into great favor, and there are a number of excellent pure bred herds in

the county. There are several dairies in the area which produce certified milk. This is shipped to Milwaukee and Chicago.

Conditions in the county are very favorable for dairying, the average farmer keeping from 10 to 15 milch cows, though there are many farms making a specialty of dairying and keeping a much larger number of cows. Milwaukee and Chicago furnish good markets for the dairy products. The silo is in very common use, the number increasing rapidly. Stave silos are the most common, though brick, stone, and cement are sometimes used in their construction.

Hog raising is carried on in conjunction with dairying, and the present high prices of pork are stimulating a greater development of the industry. The chief breeds are the Chester White, Poland China, Berkshire, and Duroc Jersey, though a large proportion of the stock is of mixed blood.

Comparatively few beef cattle are raised, though a few head are fed on a number of farms each winter. There are some pure-bred herds representing practically all the leading beef, dairy, and dual-purpose breeds, but most of the stock placed on the market is sold for breeding purposes. The raising of sheep is confined largely to the rougher portions of the area mapped as Miami gravel and Miami gravelly sandy loam, though small flocks are found in nearly all parts of the county. The rough areas are better adapted to grazing than to anything else, and as there is usually a good supply of water available, this class of land is well adapted to sheep raising. There are several breeders of pure-bred sheep within the area who have attained a wide reputation.

Many farmers raise one or two colts each year, thus supplying their own work stock and occasionally having a team to sell. One of the leading horse farms in the country, having an international reputation and doing considerable importing each year, is located in the county near Oconomowoc. The management extends the use of pure-bred sires to the people of the vicinity for a nominal sum, in order that the stock of the locality may be improved. Another horse farm is located at Menomonee Falls.

The principal farm crops now grown in this region are, in the order of acreage, hay, oats, corn, barley, rye, peas, wheat, potatoes, buckwheat, sugar beets, and truck crops. The hay consists of clover, timothy, marsh grass, alfalfa, and an occasional cutting of oats and peas. Brookfield, Genesee, and New Berlin Townships lead in the production of hay. Seeding may be done with wheat, oats, or rye. On account of an acid condition in some soils it is sometimes difficult to get a stand of clover. When the usual hay crop fails or is short, a field of oats and peas may be depended upon to furnish a good substitute.

The growing of alfalfa in this region has passed from the experimental stage. It has been demonstrated by many farmers that it can be grown successfully, and the acreage is gradually increasing. Three cuttings, and sometimes four, can be obtained each year, the total yield ranging from 3 to 5 tons per acre. Alfalfa contains a high percentage of protein, has a feeding value nearly equal to wheat bran, and is especially valuable on the dairy farm. For its production the soil should be well drained, richly manured, limed, and in good physical condition. Inoculation is advisable, though not always necessary, especially where sweet clover grows. A very satisfactory method of inoculation is to sow about 3 pounds of alfalfa seed per acre in with clover, and when that field is later sown to alfalfa, it will be thoroughly inoculated. Soil from an old alfalfa field may be used, and this is doubtless the quickest and surest way to inoculate the soil. Alfalfa may be seeded in the spring with oats and peas as a nurse crop, and these cut for hay, or it may be sown without a nurse crop in August. Both methods have given satisfactory results in the county. Twenty pounds of seed per acre is considered sufficient to insure a good stand.

Oats are grown more extensively than any other grain, though the acreage now devoted to the crop is not so great as it was 10 years ago. The average yield for the entire county is over 40 bushels per acre. Oats form the chief grain ration for horses, some is ground and mixed with other feeds for cattle, and varying amounts are sold. While Pewaukee, Ocon-

omowoc, and Genesee Townships lead in the production of oats, this crop is grown extensively in all parts of the area.

Corn is the most important crop grown, and its cash value frequently exceeds that of oats. As the dairy industry develops the acreage of corn gradually increases. Large amounts are cut for ensilage when in the glazed stage. Considerable corn is husked and fed to hogs, while some is ground and forms a part of the grain ration of the dairy cows and fattening steers. Ordinary early yellow dent is the variety most largely grown, as it is always certain to mature in this latitude. White No. 7 and Yellow No. 8 have given good results, though the white requires a longer season, and there is some danger of frost damaging this variety. The townships of Vernon, Mukwonago, and Oconomowoc exceed in the production of corn, though it is grown extensively in all parts of the survey.

The growing of barley is gradually decreasing, though it is still an important factor in the agriculture of the county. From 1900 to 1905 the acreage was more than half that of corn. A large percentage of the crop is sold, though considerable is fed on the farms. More barley is raised in Lisbon, Oconomowoc, Menomonee, and Merton Townships than elsewhere.

Rye is grown to a limited extent and is confined chiefly to the lighter soils of the area. A small amount is fed, some is ground and used in making bread, and the remainder is sold. Ottawa, Mukwonago, Summit, and Vernon Townships produce the most rye.

As stated before, only a very small amount of wheat is now grown in the area, and on account of the high price of land and the extensive development of the dairy industry, it is not at all probable that the acreage will ever be increased.

In Mukwonago Township and in a few other parts of the area, a small amount of buckwheat is annually produced.

Within the last few years the growing of peas for canning has developed quite extensively in the vicinity of Waukesha and north along the Soo Line. The canning factory is located at Waukesha, and thrashing stations are scattered about through the pea-growing section. The crop is planted at intervals so that the peas will be ready to harvest at different times during

the summer. It is necessary to cut the vines when the peas have reached a certain stage of development. If left a few days, they deteriorate rapidly. But few farmers raise more than 10 acres. The vines are cut with a mowing marhine and hauled to the thrasher at once. There they are graded and run through the machine, which breaks the pods and separates the peas. The peas which are sweet and tender, and in the best possible condition, bring the highest price. Thirty dollars per acre net is considered a good average return from this crop, though as high as $80 net has been secured under the most favorable conditions. Frequently the crop is a complete failure and will not pay for the labor expended. Farmers report better crops after land has grown peas for a season or two. As soon as the vines are cut, some of the farmers plow the land, and the same field is plowed again in the fall. This extra cultivation may account in part for the increase in subsequent yields.

Beans have never been grown to any extent, and only small patches were seen during the progress of the soil survey.

The growing of potatoes has never been developed on an extensive commercial scale. Every farmer plants a few acres and sells the surplus. It would seem that early potatoes could be profitably grown on a commercial scale, especially on the loam and sandy soils. Milwaukee provides a good market for this crop, as well as for other truck crops.

In the northeastern part of the country sugar beets are grown, and nearly every farmer in that section has from 2 to 10 acres in this crop. Beets grown on Miami clay loam produce a heavier growth and higher test than those grown on the silt loam. On well-drained areas of Clyde silty clay loam, the tonnage and net returns are greater than on any of the upland soils, though the test is usually about 2 per cent lower. The average yield of beets is 12 tons per acre, and the average test 16 per cent sugar. Besides stable manure, commercial fertilizers are sometimes used. A special brand put up by one of the packing plants, together with refuse lime, is used. The sugar factory is located at Menomonee Falls and receives beets from various parts of the State.

The trucking industry has not been extensively developed at any point in the county, though small patches of strawberries,

tomatoes, onions, celery, melons, cabbage, and the like, are grown in various parts of the survey. In the southern and southeastern parts of the area a number of farmers grow considerable sweet corn. In the vicinity of New Berlin cabbage and cauliflower are raised quite extensively. There is a pickle factory at Eagle and one at Duplainville, and cucumbers are grown in the vicinity of these places. Two hundred dollars is the maximum amount received from an acre. More strawberries are grown in the vicinity of Dousman than elsewhere.

The fruit-growing industry is not developed on a commercial scale, except at a few places where small commercial apple orchards have been planted, though on most of the farms there is a small apple orchard and occasionally a few peach, pear, cherry, and plum trees, and some small fruits. During favorable seasons a small amount of fruit is sold from many farms, but ordinarily the most of it is required for home use. The climatic conditions in this part of the state are not generally considered so favorable for fruit growing as in sections which receive the modifying influence of large bodies of water.

The type of agriculture practiced at the present time in Waukesha County, and the crops which are being grown as well adapted to the soils and the general conditions prevailing throughout this region. Considerable land has been improved and its productiveness increased by tile drains. In several places marsh land has been, or is being, reclaimed by open ditches. There is considerable variation as to crop rotation, as is seen from the discussions on the various oil types, but the rotation most common consists of corn, barley, oats, or only one of the last two—hay one or two years, and pasture one year. Grass seeding is sometimes done with the oats or barley, though when wheat or rye follow oats, as is sometimes the case, it is customary to seed with one of these crops.

As a rule the farm buildings are substantial, well painted, and kept in good repair, and while there are always some unkempt places, a large number of comfortable farm homes, with neatly kept lawns, well-cultivated fields, and good fences are evidences of thrift and prosperity to be seen throughout the county.

The labor problem is one which causes some concern, and it frequently determines the type of farming to be followed. The usual wage for eight months is $25 to $35 a month, with board. There is an industrial school at Waukesha, and on being released or paroled, employment is found for some of the boys on farms. Their wage depends upon their ability and previous experience, ranging upward from $16 a month. It is especially difficult to get competent help on the dairy farms.

The average size of farms is gradually decreasing, and, as given in the census of 1910, was 94.6 acres. As the average size decreases, the methods followed become more intensive, and greater returns per acre are received.

Many of the small towns and villages in the area are made up largely of retired farmers. The census of 1900 states that 73.2 per cent of the farms are operated by the owners. By 1910 this had increased to 78.3 per cent. The share system prevails in renting. When the tenant furnishes everything, one-third of the crop is given as rent. When the landowner furnishes stock, tools, and seed, the crops are equally divided. The canning factory at Waukesha sometimes rents land on which to grow peas and pays $5 an acre for it. Comparatively little cash renting is done. In one case a tract of 120 acres, half under cultivation and the remainder about equally divided between woodlot, rough pasture land, and marsh, from which hay could be cut, rents for $350 a year.

The value of farm lands in the county depends upon the character of the soil, topography, location, and improvements. The lowest in value consists of Miami gravel, Miami gravelly sandy loam, and unreclaimed marshes, prices for which range from $10 to $50 an acre. On the Miami clay loam, silt loam, and loam types, which are highly developed, land values range from $75 to $150 an acre.

While the agriculture of the area is highly developed and in a prosperous condition, there are, nevertheless, some changes and additions which might be made advantageously. A few general suggestions are given here, but the more specific recommendations are given under the separate soil types to which they refer. Since the area surveyed is favorably located in

regard to markets, well supplied with railroads, and admirably adapted to dairying, it is recommended that this already important industry be still further developed. Catering to special classes of trade in milk production is proving profitable. Sanitary methods of handling the milk and in caring for stock should be followed more generally.

The number of silos should be increased, and the acreage devoted to corn for ensilage extended. Alfalfa is an excellent feed for dairy cows, and, as it can be successfully grown here, its production should be greatly extended. Where the soils are found to be acid, a more liberal use of lime is recommended. This may be applied directly to the cultivated fields or may first be sprinkled in the stables to improve their sanitary condition and reach the land when the manure is applied, thus serving a double purpose. Whenever it is possible to do so, manure should be spread upon the fields as rapidly as made. When this can not be done it should be stored in a shed to prevent loss.

While this region is not generally considered as adapted to commercial fruit growing, it is suggested that more attention be given to putting out small orchards for home use. On every farm there should be a few trees of the different kinds of fruit, so there would always be enough for home consumption. There are a large number of good orchard sites throughout the county, and it would seem that apples and cherries might well be grown on a commercial. The growing of raspberries, blackberries, currents, strawberries, etc., could profitably be extended. The nearness to Milwaukee should be considered not only as providing a ready market, but also as being a point from which labor could be readily secured for handling these crops.

On many of the soils trucking could be profitably developed. This industry could be extended, especially on the lighter types, which are not so well adapted to general farming and dairying. Strawberries, melons, cucumbers, tomatoes, and a few other truck crops are being successfully grown on small acreages on the light soils, and cabbage does well on Clyde loam and silty clay loam. Where a water supply is convenient, small irrigation systems could be established and water applied to these special crops during the dry months.

The marshes, of which there are many, should be reclaimed, thus adding thousands of acres of valuable land to the resources of the county. This matter should be given careful attention by the land owners, because when improved these areas will produce very profitable yields.

CHAPTER X.

CLIMATE.[1]

"Among the factors which influence the agriculture of a state none is more important than climate. The class of crops which can be grown is largely determined by the length of the growing season, and the amount and distribution of the rainfall." Any one of these factors may determine the type of farming which can be followed to best advantage.

"The distribution of rainfall over Wisconsin is remarkably uniform, the average yearly precipitation having a range of from 28 to 34 inches, while the mean for the state as a whole is 31 inches. This is a slightly heavier rainfall than is received by eastern England, northern France, most of Germany, Sweden, and the Dundee Valley. As compared with other portions of this country, Wisconsin has a total rainfall equaling that of central Oklahoma and Kansas, northern Iowa, Michigan, Northwestern New York, or the Puget Sound Basin of Washington. But owing to its northerly location, the lessened evaporation probably makes the precipitation as effective as that of Arkansas, Illinois, or Virginia."

The local distribution of rainfall varies, however, from year to year, some sections receiving more rain one year, and other sections more in other years. The variation is caused largely by the movement of cyclonic storms. The average rainfall for the entire state during the driest year was 21.4 inches, and for the wettest year 37 inches.

"Of equal importance, in agriculture, to the total rainfall, is its seasonal distribution, and in this respect Wisconsin is un-

[1] This chapter has been taken largely from Wisconsin Bulletin 223 on The Climate of Wisconsin and its Relation to Agriculture. This bulletin should be consulted if more information is desired concerning climate. All quotations indicated are taken from this bulletin.

usually fortunate, since about half of the total rainfall comes in May, June, July, and August, and nearly 70% from April to September, inclusive. June has the heaviest rainfall, averaging 4.1 inches, while July averages 4 inches and May 3.9 inches. The precipitation during the winter, on the other hand, is slight; December, January, and February each averaging from 1 to 1.5 inches of rain and melted snow. The average rainfall for the state during winter is 3.9 inches, during spring 8.3 inches, during summer 11.4 inches and during autumn 7.4 inches. Most of the rainfall occurs just preceding and during the period of plant growth, thus being received by the crop at the most effective time. Wisconsin receives during the growing season, April to September, inclusive, an average of 21 inches of precipitation, which is as much rain as that received during the same months by eastern Texas, Illinois, Ohio, or eastern New York.. The small winter precipitation in Wisconsin, mostly in the form of snow, on the other hand, causes virtually no leaching of fertility from the soil, or erosion.''

Another phase of rainfall distribution of great importance is its variation within a period of a few weeks. Frequently periods of drought and periods of unusually heavy rainfall occur, continuing for one to four weeks and occasionally longer. Observations taken at Madison by the Weather Bureau over a period of 30 years from 1882 to 1911, inclusive, show that there are on the average three ten day periods during each growing season when the amount of rainfall is so slight that crops on a reasonably heavy soil (Miami silt loam) actually suffer from the lack of moisture. In Waukesha County the conditions are practically the same.

The greater portion of Waukesha County lies within the "The Rock River Basin", which is recognized as forming one of the eight climatic provinces in Wisconsin. The area surveyed lies on the east border of the Basin and is influenced to a slight extent by Lake Michigan. "The Rock River Basin has the longest growing season in the state, averaging about 170 days, which is as long as that of central Illinois, longer than central Indiana or Ohio, and about equal to the valley of Virginia and central Maryland. The annual temperature curves also show

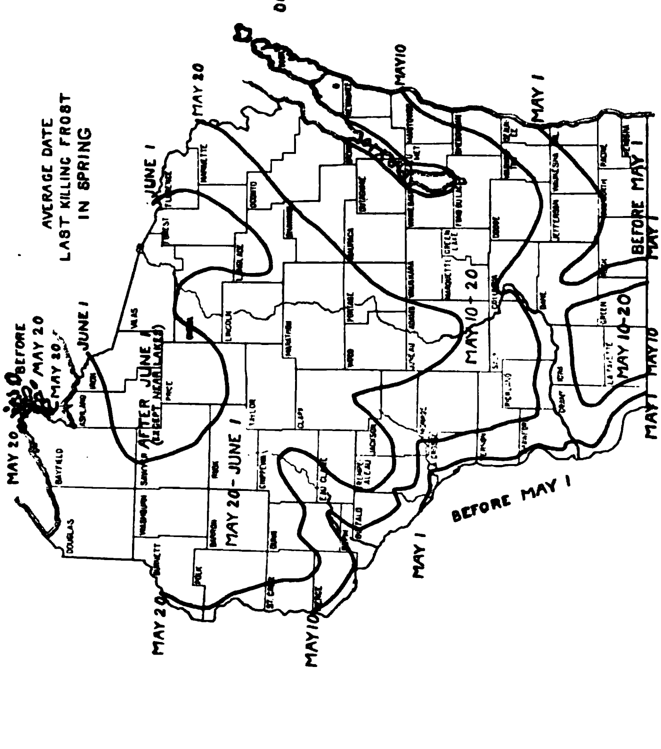

FIG. 5. LAST KILLING SPRING FROST.

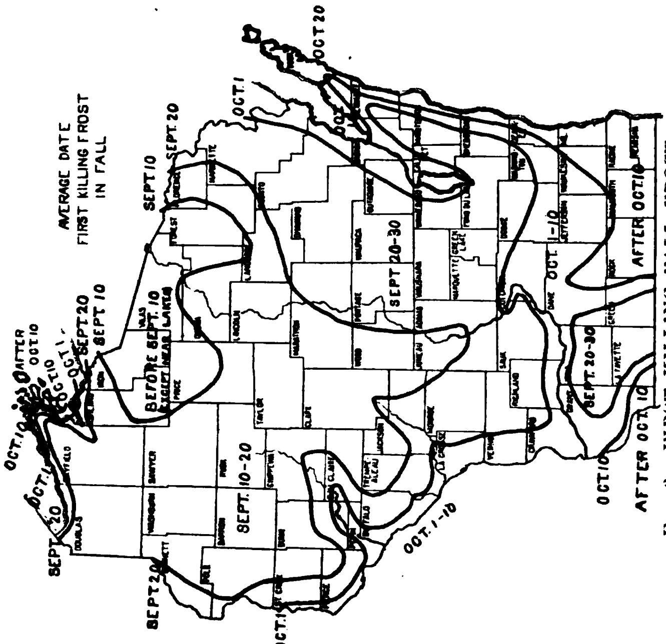

FIG. 6. FIRST KILLING FALL FROST.

These maps have been prepared from the original monthly reports of the observers of the U. S. Weather Bureau for the past 12 years, supplemented by private records.

here a northward bend, and though the winters (20°) are cooler than along the lake, the springs (45°) and the summers (70°) are warmer. Hence this section is the best corn area in the state. The temperature of the Rock River basin in summer is similar to that of northern Illinois, Indiana, Ohio, and southeastern Pennsylvania, while in winter it resembles southern Vermont, northern Iowa, or southern Montana. During seven summer days, on the average, the thermometer may go as high as 90°, and during five winter mornings fall to 10° below zero or lower.. The average rainfall ranges from 31 inches at Madison, to 35 inches at Brodhead."

The average snowfall is about 32 inches, and under normal conditions crops of winter wheat, rye, clover and alfalfa are well protected by a covering of snow. When the snowfall is light such crops are frequently damaged by freezing and thawing.

By reference to figures 6 and 7 it will be observed that the average date for the last killing frost in the spring is about May 1st, while the average date of the first killing frost in the fall is about October 10th. This gives an average growing season of about 162 days for Waukesha County. From the data given on these two figures the length of the growing season in any part of the state may be readily determined.

The prevailing winds during winter are from the west and north, and during summer from the west to southwest. This region is seldom visited by storms of a destructive nature, though high winds are quite common during March. The climate is healthful, and especially delightful during the summer months. The water supply is abundant and of very good quality. On account of the mineral springs and the many beautiful lakes, large numbers of people are attracted to Waukesha County each year to spend the summer months.

SUMMARY

Waukesha County lies in the southeastern part of Wisconsin and comprises an area of 560 square miles or 358,400 acres. The surface varies from level to rough and hilly.

The drainage is into Lake Michigan from the eastern side of the county, and into tributaries of the Mississippi from other portions.

The first settlement was made in 1834, and the county was established in 1846. The early settlers were chiefly English, Germans, and Irish, coming from the Old World and from the older States. Waukesha, the county seat, is 20 miles from Milwaukee, and 100 miles from Chicago.

The county is well supplied with steam, electric, and wagon roads, and all parts of the survey are provided with telephone and rural free-delivery service.

The soils of Waukesha County have all been derived from the mantle of glacial drift which covers the surface of the entire region to a depth varying from a few feet to over 300 feet. Twenty types, including Peat (with included areas of Muck) and Meadow, were mapped.

The Miami series, covering over half the county, consists of the light-colored glacial material. Seven types were found belonging to this series. These soils are fair to good general farming soils.

The Plainfield series consists of the light-colored soils of the outwash plains and filled-in valleys, and is represented in the present survey by four types. The silt loam and loam are good general farming soils. The fine sandy loam and sand are not extensive types.

The Waukesha series includes the dark-colored soils of the out-wash plains, and is represented here by the loam and gravelly loam type. It is largely prairie, level to undulating,

and a good general farming soil, though somewhat droughty. Waukesha gravelly loam is of limited extent, occupying chiefly terraces bordering the Eagle Prairie.

Two Carrington soils, the loam and clay loam, are found. The Carrington clay loam is an extensive type and a good soil in Racine County, but occupies only one small tract in the southeastern part of Waukesha County.

Soils of the Clyde series occupy old lake beds. They contain a high percentage of organic matter. Three types are represented in this survey: the silty clay loam, loam, and sandy loam. The soils need drainage. When reclaimed they are very productive.

Peat (with included areas of Muck) occupies the numerous marshy and swampy areas throughout the county. Few areas have been drained, though most of them could be reclaimed and made highly productive.

Meadow consists of low-lying strips of land adjacent to streams and subject to frequent overflow. Crops on such areas are uncertain.

The type of agriculture followed consists chiefly of general farming in conjuction with dairying. About one-half of the milk produced goes to the creameries and cheese factories. Large quantities are shipped to Milwaukee and Chicago.

Numbers of hogs are raised on the dairy farms, and many farms make a specialty of raising pure-bred cattle, horses, sheep, or swine.

Hay (clover and timothy), oats, corn, barley, rye, and peas are the principal crops. The growing of alfalfa has just emerged from the experimental stage. It does well on a variety of soils. Much of the corn is grown for ensilage. Peas are grown for the canning factory at Waukesha, and sugar beets for the sugar factory at Menomonee Falls. Some truck crops are produced.

The mean annual precipitation is 31.9 inches. There is an average growing season of 162 days.

KEEP THE MAP

The Experiment Station will publish bulletins from time to time, dealing with the management of the different types mapped, so that some way should be found by each person receiving a copy of this report to keep the map permanently. If the map is folded in such a way as to have the part you are interrested in of a convenient size, and then have a simple frame with glass made to hold it, it can be kept indefinitely. Since some of the colors fade after being exposed to strong light for a long time, it would be a good plan to have a protecting flap of dark cloth over the map when not in use.

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

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SOIL SURVEY IN COOPERATION WITH THE COLLEGE OF AGRICULTURE,
H. L. RUSSELL, DEAN.

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SOIL SURVEY

OF

IOWA COUNTY

WISCONSIN

BY

A. R. WHITSON, W. J. GEIB, T. J. DUNNEWALD AND EMIL TRUOG

OF THE

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

AND

CLARENCE LOUNSBURY

OF THE

UNITED STATES DEPARTMENT OF AGRICULTURE

SURVEY CONDUCTED IN COOPERATION WITH THE UNITED STATES
DEPARTMENT OF AGRICULTURE, BUREAU OF SOILS,
MILTON WHITNEY, CHIEF.
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY.

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INTRODUCTION

Before the greatest success in agriculture can be reached, it is necessary that the farmer should have a thorough knowledge of the soil upon his own farm. A soil may be well adapted to one crop, and poorly adapted to another crop. Clover will produce a vigorous growth and profitable yields on the average loam soil which contains lime and is in a sweet condition; but on a sandy soil which is sour, or in an acid condition, clover will not make a satisfactory growth. We may say, therefore, that failure is certain to be invited when such important facts are disregarded, or overlooked. The degree of success which it is possible to win on any farm is in direct proportion to the practical knowledge possessed by the farmer concerning the soil and its adaptation to crops. A thorough knowledge of the soil is as essential to the farmer as a knowledge of merchandise and business methods is to the merchant.

The State of Wisconsin, working in coöperation with the United States Department of Agriculture, is making a careful study of soils and agricultural conditions throughout Wisconsin, and is preparing soil maps and soil reports of all counties in the State. A soil map shows the location and extent of the different kinds of soil. Tracts of 10 acres and over are mapped, but often areas of even smaller extent are shown. The soil map is prepared by trained men, who go over a county thoroughly, and examine the soil by making a sufficient number of borings to a depth of 36 inches to keep account of all variations. A report is also made, to accompany and explain the map, and this is based upon a careful study of the soils within the region surveyed, and upon such other features as have a direct bearing upon the agriculture of the area.

It is the object of this survey to make an inventory of the

soils of the State, and to be of practical help to farmers by locating and describing the different soils, by determining their physical character and chemical composition, and by offering suggestions for their management, based upon the work of the Soil Survey within the area, covered in the report, and upon the results of field tests made by the Experiment Station.

Soil fertility depends upon two factors: first, upon the physical characteristics of the soil, such as water holding capacity, workability, etc., and second, upon the chemical composition of the material composing the soil. The chemical composition depends upon the mode of origin of the soil, and the source of material from which the soil is derived.

Water holding capacity, and other physical properties of soil all depend chiefly upon *texture,* which refers to the size of the individual soil grains, or particles. A coarse sandy soil, for example, will not retain moisture so long as a loam soil, or clay loam, because the finer the soil grains, the greater will be the total soil-grain surface area to which moisture may adhere. Texture is determined in the field by rubbing the soil between the thumb and fingers, and with experience one soon becomes expert at judging the size of soil grains. This field judgment is verified in the laboratory by a *mechanical analysis,* which is made by a simple method of separating soil grains into different groups, of which there are seven. These are known as clay, silt, very fine sand, fine sand, medium sand, coarse sand, and fine gravel.

A chemical analysis is also made of the soil to determine the amounts of various essential plant-food elements which are present. A chemical analysis shows whether the soil contains a large store of plant food, or only a small quantity, and it indicates which kinds of plant food will probably be needed first. The amount of organic matter in the soil is also determined, and tests are made to show conditions relative to soil acidity.

SOIL CLASSIFICATION.

Soils are grouped according to texture into soil classes, a *soil class* being made up of soils having the same texture, though differing in other respects. A fine sand, for example, may be light colored and of alluvial origin, while another fine sand may be dark in color and of residual origin, while a third fine sand may have been blown into sand dumes by the wind, yet all of these soils would belong to the same class, because the greater proportion of the soil grains have the same size or texture. Thus we may have different kinds of clays, loams, sands, etc., and the class to which any soil will belong depends upon the size of the individual soil grains of which it is composed, and not upon its color, origin, topographic position, or agricultural value.

SOIL CLASSES

SOILS CONTAINING LESS THAN 20% SILT AND CLAY

Coarse sand.—Over 25% fine gravel and coarse sand, and less than 50% of any other grade of sand.

Sand.—Over 25% fine gravel, coarse and medium sand, and less than 50% fine sand.

Fine sand.—Over 50% fine sand, or less than 25% fine gravel, coarse and medium sand.

Very fine sand.—Over 50% very fine sand.

SOILS CONTAINING BETWEEN 20–50% OF SILT AND CLAY

Sandy loam.—Over 25% fine gravel, coarse and medium sand.

Fine sandy loam.—Over 50% fine sand, or less than 25% fine gravel, coarse and medium sand.

Sandy clay.—Less than 20% silt.

SOILS CONTAINING OVER 50% OF SILT AND CLAY TOGETHER

Loam.—Less than 20% clay, and less than 50% silt.

Silt loam.—Less than 20% clay, and over 50% silt.

Clay loam.—Between 20 and 30% clay, and less than 50% silt.

Silty clay loam.—Between 20 and 30% clay, and over 50% silt.

Clay.—Over 30% clay.

Soils may be grouped in another way. Where soils are closely related through similar sources of the material from which derived, mode of origin, topographic position, etc., so that the different soils constitute merely a graduation in texture of otherwise uniform material, such a group is called a *soil series*. It corresponds to the family which is made up of different individuals having the same parentage. The Miami series, for examples, includes light colored, glacial material where the soils

have been derived largely from the underlying limestone, and the soils in the series range in texture from a clay loam to sand and gravel. The Plainfield series includes light colored soils in regions where no limestone is present, and where the material occurs as outwash plains or stream terraces. The soils in this series also have a wide range in texture. The name used for a soil series usually indicates the locality where that particular series was first recognized and mapped by the Soil Survey.

By uniting the name of the *soil class*, which refers to texture. with the name of the *soil series*, which refers chiefly to origin, we get the *soil type*, which is the basis or unit of classifying and mapping soils. A *soil type*, thus, is a soil which is uniform throughout its entire extent in texture, color, topographic position, and other physical properties, and having a distinct agricultural unity, that is, being adapted to the same crops, and requiring the same treatment. It is also uniform in the source of material from which it is derived, and the mode of origin which, taken together, determine the chemical composition. Since the soil type is the unit in classifying and mapping soils, and the basis upon which experimental work should be conducted, every farmer should be familiar with the soil types on his farm, and their leading characteristics.

SOIL SURVEY OF IOWA COUNTY, WISCONSIN.

CHAPTER I.

GENERAL DESCRIPTION OF AREA.

Iowa County is situated in the southwestern part of Wisconsin, in the second tier of counties north of the Illinois line. The Wisconsin River forms its northern boundary, separating it from Sauk and Richland Counties. On the east are Dane and Green Counties, on the south Lafayette County, and on the west Grant County. The county has an area of 482,560 acres, or 754 square miles, and is nearly square, being 30 miles broad from east to west and approximately 25 miles from the river to its southern boundary.

The topography is that of a deeply dissected peneplain, being characterized by elevated undulating prairies and rougher, more rugged hill country. Military Ridge, which runs in a general way from east to west through the middle of the county as a broad, elevated ridge with mainly southward projecting lobes, is a remnant of an original upland plain and divides the drainage of the country, sending it southward by tributaries of the Pecatonica River into Rock River and the Mississippi and northward into the Wisconsin River and thence into the Mississippi.

The main ridge widens out in the western part of the county into a nearly level plain, which is some 10 miles wide along the western boundary. The stream valleys just south of the ridge are bounded by gentle slopes, which become somewhat steep as the valleys widen in the southernmost part of the county. To the north of the ridge the valley sides are much

more abrupt and the topography rapidly becomes quite rugged, culminating in the bluffs along the Wisconsin River. Rocky ledges and precipitous ravines and hollows are here common along the upper stream courses.

The central ridge and projecting lobes have an elevation of 1,100 to 1,200 feet. The Wisconsin Valley bottom has an elevation of slightly over 700 feet, while stream beds in the extreme southern part of the county have an approximate elevation of 900 feet. West Blue Mound, located on the ridge at the eastern edge of the county, is the highest point, both in the county and in this part of the State, and has an elevation of approximately 1,700 feet.

The larger streams emptying into the Wisconsin Valley retain an elevation of 800 feet or less 8 miles back from the river, their greatest descent being accomplished in the first 4 or 5 miles north of Military Ridge.

The Wisconsin River, which forms the north boundary of the county, is the largest river within the State, and but for the sandy character of its bed and of the valley in general could be made navigable. Shifting sand bars and a shallow, ever-changing channel have so far discouraged all navigation within the county. The streams in this county which flow into the Wisconsin River are small creeks supplied mainly by springs on the north side of Military Ridge. These streams from west to east, successively, are Underwood, Otter, Sneed, Wyoming, Mill, and Blue Mound Creeks. Streams flowing south from the ridge are tributaries of the Pecatonica River, which traverses part of the southern edge of the county.

The Chicago, Milwaukee & St. Paul Railway line follows the river valley on the north edge of the county. Fifteen miles south, the Chicago & North Western Railway follows the prairie ridge from east to west through the county. A branch line of the Illinois Central Railroad traverses the county from its southwest corner to Dodgeville. The Mineral Point & Northern Railway follows a branch of the Pecatonica River from Mineral Point north to Highland. These railroads furnish good transportation facilities for the county.

The population of the county is 22,497, the foreign born being largely English, German, Norwegian, and Irish. Zinc and

lead mining early attracted people to the county. Many of the first settlers were from the South; later many came from more eastern States.

Dodgeville, the county seat, with a population of 2,200, and Mineral Point, in the southern part of the county, with 3,200 are the most important towns. Cobb, Edmund, Rewey, and Ridgeway on the prairie, and Arena and Avoca in the Wisconsin Valley, are the more prosperous of the smaller towns.

Excepting when snow is deep in winter, the prairie roads are good the year around. Roads on Knox silt loam are hard in dry weather, but become rather heavy in wet weather. On the sands they are often poor, but where surfaced with heavy material they are very satisfactory.

SOILS.

Iowa County is situated in the area which was not covered by ice during the glacial period. This region includes a large part of the southwestern part of the State and small portions of the three adjoining States.

The soils of this county were chiefly formed by the weathering of the underlying rocks, which are for the most part limestones with thinner beds of sandstone. Over the higher parts of the county, however, there is found an extensive layer of fine silt loam, largely free from stony material and known to geologists as "loess." This loess was brought to this section and deposited by wind. Over the more level, prairie-like areas on the western portion of Military Ridge, there has been developed a dark loess-like soil high in organic matter, covering the light colored loess which thus becomes the subsoil. This dark soil is called Marshall silt loam. On the slopes toward the north and south, however, this blanket of light colored loess becomes the surface soil, constituting Knox silt loam. Along the slopes of the highland this cover of loess becomes mixed with residual material derived by weathering from the underlying limestones and sandstones, so that very generally it would be difficult to say whether the soil was more largely of loessial or residual origin. Along the beds of valleys are occasionally found patches of loess varying in extent

from a few acres to 2 or 3 square miles. This material was washed down from the upland and redeposited in the valleys, and the large amount of organic matter present gives this material a dark color. This is the region of Wabash soils. Where material has been washed down from the loessial uplands and deposited as light colored terraces or as colluvial slopes, such soil has been classed in the Lintonia series. In addition to the Marshall silt loam and Knox silt loam, there are soils of dark color similar to the Marshall, but lying on a subsoil which is practically entirely residual material from underlying limestones and contains no loess. This soil has been named Dodgeville silt loam. Where the residual material from the sandstone rock develops sandy soils of sufficient extent, they have been mapped as the Boone series. The larger part of the terraces of the Wisconsin Valley consist of sandy and gravelly soils, the material of which was brought down by the river itself, probably during the latter part of the glacial period, when large volumes of water were formed by the melting ice. These light colored terrace soils are classed with the Plainfield series. There are also areas of Muck on these terraces caused by the growth and decay of a rank vegetation in low places, chiefly at the mouth of tributary streams. There are also some small areas of Dunesand caused by the blowing of the loose sands.

The following table gives the names and extent of the several types of soil. Their distribution is shown by means of colors in the accompanying map.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Knox silt loam.........	177,856	51.3	Boone fine sandy loam	5,440	1.1
Steep phase........	69,504		Plainfield sandy loam	4,864	1.0
Rough stony land......	57,280	11.9	Wabash loam	4,160	.9
Dodgeville silt loam...	56,128	11.6	Muck	2,432	.5
Marshall silt loam.....	46,080	9.6	Lintonia silt loam	2,368	.5
Wabash silt loam	36,288	7.5	Dunesand	2,240	.5
Plainfield sand.........	9,920	2.0			
Meadow	8,000	1.6	Total............	482,560	....

CHAPTER II.

GROUP OF UPLAND SILT LOAM SOILS.

KNOX SILT LOAM.

Description.—The surface soil of Knox silt loam to an average depth of 10 to 12 inches consists of a light-brown or grayish friable silt loam having a soft, floury feel. The amount of organic matter in the soil is comparatively small, as is indicated by the light color. The subsoil consists of a light-brown or yellowish brown compact silt loam in which the clay content gradually increases with depth until a silty clay loam is reached at a depth of from 20 to 24 inches. This heavy material usually extends to the underlying rock which is covered to a depth of from 3 to 20 or more feet.

The depth of the surface soil is somewhat variable owing to the topographic position which this soil type occupies. On the steeper slopes the surface has been eroded to varying degrees, and frequently the heavy subsoil is exposed. Along the lower slopes the wash from the higher portions of the type has accumulated so that the depth in such places is greater than usual. Along the tops of some of the narrow ridges the soil is also shallow, and the plow frequently turns up the heavy subsoil. The texture of this type of soil is remarkably uniform.

While this soil is quite compact, it is subject to severe erosion on the steeper slopes. Hard rains start ditches in cultivated fields which subsequently become so deep that the land is ruined for the production of cultivated crops. When the ditches are once started it is difficult to prevent their progress. Brush and straw are sometimes thrown into them to catch the soil as it crumbles away, and to retard further washing, but with only partial success. On the map the steep and rougher

parts of the type are indicated by cross-lining over the color that indicates the main body of the type.

Extent and distribution.—Knox silt loam is far the most extensive type in the county, covering about 51.3 per cent of the area. It predominates on the uplands north of Military Ridge. South of the ridge it projects into the Dodgeville and Marshall silt loams along stream depressions, widening from such places into broad areas. Elevation does not seem to be a controlling factor in its development, for it is found on some hills and ridges equal in elevation to those of the prairie types. It is found about and west of Mineral Point and predominates in the southeastern part of the county.

Topography and drainage.—The surface of the type is irregular, varying from gently rolling to rolling, and is hilly and even broken in places. As a whole, it is the roughest type in the county with the exception of the Rough, stony land which is largely non-agricultural. The topography is more rough and broken in the northern than in the southern part of the county. A considerable portion of the type consists of ridges and steep slopes upon which erosion is an important factor. Owing to the uneven surface features, the natural drainage is good; and it is not at all likely that tile drains will ever be needed over any portion of the type.

Origin.—The uniform character of this type and the buff color of the subsoil, together with other field characteristics, indicate that this soil is largely of loessial origin. The material is very much like loess in character, though its exact geological origin is not thoroughly understood, and it is quite probable that it is considerably modified at least by residual material derived from the consolidated rocks of the region. In some places where the loesslike covering is thin, and where the underlying rock is limestone, it is very evident that the residual material from this formation has influenced the type to a limited extent. In other places, however, the evidence is not so clear, and the pure loessial material appears to be many feet in depth.

FIG. 1. VIEW OF KNOX SILT LOAM, SHOWING CHARACTERISTIC TOPOGRAPHY AND FARM BUILDINGS.

This type of soil covers over half of Iowa County. The foreground, and the top of the ridge near buildings, represents the typical soil, while the steep slopes leading to ravine on right are characteristic of the steep phase.

WISCONSIN GEOL. AND NAT. HIST. SURVEY. PLATE I

FIG. 2. VIEW OF STEEP SLOPE SHOWING ONE METHOD OF CROPPING TO PREVENT EROSION.

A cultivated crop may be grown on the ridge top, or gentle slope, as shown on the left, but on the steeper slopes the fields should be kept in grass as much as possible, as indicated in center of view. Where the slope is very steep, as on

Native vegetation.—Originally the area of Knox silt loam was all timbered, and portions still have a growth of forest in which white, bur, and black oaks predominate. Maple, poplar, hickory, white birch, and basswood are also common species. Hazel brush is abundant on many of the steep slopes.

Agricultural development.—Dairying is the chief interest on this type of soil. Corn yields 30 to 60 bushels per acre, averaging 40 bushels. Where corn, or any tilled crop, is grown on the same land more than one year in succession, washing takes place even on comparatively gentle slopes. On some of the steeper slopes no cultivated crops are grown, and in places the native forest growth has been allowed to stand. Consequently, careful rotation and intelligent cultivation are necessary. Oats and barley yield 25 to 50 bushels per acre, averaging 30 bushels. Barley is regarded as a surer crop than oats. Wheat is now but little grown, though yields of 10 to 20 bushels can be secured. One to two tons of hay per acre is the ordinary return. Alfalfa has been tried in small patches with some success. Where the soil is deep and fairly productive, this crop should succeed. The pastures are in general excellent, but on bare ridges, where the soil is apt to be thin, they are likely to fail in dry weather.

Clovers are generally seeded with other grasses, and are also made use of in maintaining and increasing the productiveness of the land. Some farmers complain of poor stands of red clover and get better results with alsike. Medium red clover is, however, the most common and is more beneficial to the land than alsike.

Farm manures are well utilized and usually applied with manure spreaders. No commercial fertilizers are used. Farmers, as a rule, are prosperous, fences and buildings are in good repair, and a large number of modern barns are being built. Silos can not be said to be in general use, though many farms have them. Dairying has resulted in marked improvement in conditions on this type.

Methods of improvement.—Chemical analysis of Knox silt loam shows it to contain, on the average, about 900 pounds of

phosphorus in the surface 8 inches of an acre, about 35,000 pounds of potassium, and 2,700 pounds of nitrogen. These analyses are on soils taken from fields which have had the average history of farms in Iowa county. The virgin soil of that section contains considerably more phosphorus, but the years of cropping to small grains which occurred previous to the present decade have removed important quantities of that element. From now on it will be necessary for farmers on this type of soil to consider carefully the means of retaining and increasing the phosphorus content of their soils. The total potassium is sufficient to meet any demands, but its availability will depend upon the supply of actively decomposing organic matter; and the improvement of this type as a whole calls chiefly for the addition of green manuring crops in the system of rotation followed, unless, indeed, unusually large amounts of barnyard manure are available through intensive stock farming. The underlying rocks of this entire region are chiefly limestone, and where fields are on the lower slopes of hills, they are rarely acid, since lime is brought to them from the rocks lying under the higher portions of the hills. On the ridges, however, more or less acidity has developed, and each farmer should make the test for acidity * on each field, especially with reference to the growth of clover and alfalfa. Where an acid condition is found to exist, from 1,200 to 2,000 pounds of ground limestone per acre should be applied.

The question of preventing erosion is one which should be carefully considered by all farmers on Knox silt loan. It is a difficult matter to check erosion and repair the damage when once it has made considerable headway, but there are a num-

* As a number of the soils in Iowa County are in an acid condition and would be greatly benefited by the application of some form of lime, every farmer should know how to test his soil for acidity. Bulletin 230 of the Wisconsin Experiment Station on "Soil Acidity and Liming" gives the following method which can be readily applied." A very simple and reliable method to detect soil acidity is by the use of the blue litmus paper, which can be secured of any good druggist. Take a handful of moist soil and form it into a ball. Break the ball into halves and place a piece of blue litmus paper in the center on one of the halves, and cover over with the other half. After 5 minutes break the ball, and if the paper is pink in spots or over the whole end, the soil is acid." "Soil acidity is also usually indicated by the growth of certain weeds, such as sheep sorrel, horse-tail rush, corn spurry, and wood horse-tail."

ber of ways by which washing may be prevented, or at least reduced to the minimum. Figure 2, Plate I, shows an arrangement of fields which will tend to prevent erosion on the steep slopes. On the tops of ridges and on gentle slopes, cultivated crops may be grown in rotation with other crops in the usual way; but when the slope becomes so steep that the bare ground would wash to any extent, fields should be used for hay or pasture as much of the time as practicable. Where the slope is so steep that modern farm machinery cannot be used, no cultivated crops should be grown, but the fields should be kept as permanent pastures. If such slopes are in timber they should be allowed to remain so. In some instances it would doubtless be advisable to reforest some of the steep slopes which have been cleared.

Where it is found necessary to cultivate steep land, the plow should follow the contour of the hill, and narrow strips of sod should alternate with the cultivated strips. In some places strips of sod may be left running with the slope at points where most of the run off water flows. Erosion at such places will thus be held in check while the remainder of the field is being put into a grain crop and reseeded.

The dairy industry could well be developed to a higher degree on this type. More silos should be constructed, and more attention given to the growing of alfalfa. By supplementing the supply of stable manure with green manuring crops the supply of humus forming material in the soil will be enlarged, and its productivity increased.

The following table gives the average results of mechanical analyses of the soil and the subsoil of this type:

Mechanical analyses of Knox silt loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0.0	0.5	0.5	1.5	17.1	65.7	14.3
Subsoil	.0	.2	.3	1.0	7.5	67.3	23.5

MARSHALL SILT LOAM.

Description.—Marshall silt loam is a dark-brown or, occasionally, black silt loam, from 8 to 12 inches in depth, resting on a subsoil of compact silt loam of a light-orange, brown, or buff color, which gradually becomes somewhat lighter and the texture more compact with depth. Often the lower subsoil, though silty, has a close, rather compact claylike structure, and a layer of heavy, reddish-brown clay, containing angular, cherty limestone fragments, lies next to the rock. Where this type of soil is relatively thin, the clay stratum over the rock is in places displaced by 1 or 2 inches of yellowish sandy material due to the locally granular, crumbly character of the underlying Galena limestone. The soil is free from stones, gravel, or coarse materials. It is generally friable, loose, and contains a relatively large proportion of organic matter.

Extent and distribution.—This type is confined to the western portion of the county. The boundary between it and Dodgeville silt loam, which is placed between Dodgeville and Edmund on Military Ridge, is a more or less arbitrary one, as the two types grade imperceptibly into each other, with no sharp line of demarcation. As indicated on the map, the Chicago & North Western Railway forms a fairly good boundary on the north of the type, except below Highland. An elevated ridge bearing this soil projects north from the main prairie area to Highland. Another level ridge extends southward along the western border of the county. From near Dodgeville, westward, the prairie soil becomes deeper. The soil material ranges in depth from 3 to 4 feet near Dodgeville, to 15 or 20 feet in depth west of Edmund. A depth of 30 feet is reported in many places in the western part of the county.

Topography and drainage.—This type of soil occupies the upland prairie sections of the county, which consist of elevated ridges and level to gently rolling plains. None of the type in the county is found below an elevation of 1,000 feet above sea level. The surface is usually undulating or gently rolling, though on the broader divides it may be nearly level. There

is good natural drainage, and there is little or no necessity for artificial drainage on any of the type.

Origin.—Marshall silt loam in this area is derived from an intermixture of residual soil, from the underlying Gelena limestone, and transported silty material which is largely of loessial origin. Over the eastern portion of the type the loessial covering is thin, and the underlying residual material is often exposed in road cuts or on eroded slopes. To the west the covering becomes deeper, and along the west county line, it has a depth of over 20 feet.

Native vegetation.—This type embraces a portion of the prairie region of Iowa County and has never supported a forest growth. The native vegetation consisted chiefly of prairie grasses, with only a very limited tree growth along the borders of the prairie and adjoining stream courses.

*Agricultural development.**—Marshall silt loam is a good soil for general farming, and all portions of it are under cultivation and highly improved. The raising and feeding of beef cattle is an important industry on this type and many of the farmers turn off a considerable number of fat steers every year. Dairying is not carried on as extensively as in other parts of the area on some other types, but it appears to be increasing in favor, and this industry, along with general farming, forms the chief type of agriculture. While all of the general farm crops common to this region are successfully grown, it is probably better adapted to corn than to small grains. Corn is extensively grown and yields from 50 to 70 bushels per acre. In some localities it has been grown continuously for many years on the same fields, with no diminution of yield, care being taken to manure the land each year. Oats and barley yield from 40 to 50 bushels, barley producing a little better than oats. Hay is of good quality, yielding $1\frac{1}{2}$ to 2 tons. Wheat and rye are not extensively grown. Wheat will yield 15 to 20 bushels per acre. A few years ago the chinch bug became so troublesome as greatly to discourage

* For methods of improvement of Marshall silt loam see page 25.

wheat growing. Most of the wheat grown is sown in the fall, though some spring varieties are grown. Hog and sheep raising are quite largely carried on.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analysis of Marshall silt loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0.0	0.5	0.3	0.6	23.1	54.0	20.9
Subsoil	.0	.2	.2	.3	.3	68.0	31.1

DODGEVILLE SILT LOAM.

Description.—The surface soil of Dodgeville silt loam is a dark-brown to nearly black silt loam ranging from 8 to 10 inches in depth. Where typically developed, it is generally friable, free from stones on the surface, and contains a considerable amount of organic matter. The subsoil is a compact silt loam of a light reddish brown or yellowish color, becoming more compact in structure with increase in depth. This type is often less than 3 feet deep, and in such cases the subsoil next the rock often consists of a heavy, dense, reddish-brown clay, containing angular, cherty limestone fragments. Again, this clay stratum may be nearly absent and immediately over the rock there occurs an inch or two of material having the appearance of a yellowish sand, but which is really composed principally of sharp calcium-carbonate crystals, easily disintegrated.

On the eastern edge of the county this soil is rather shallow, probably averaging less than 3 feet in depth, though in many places it is more than 3 feet deep. The areas east of Mineral Point will average rather more than 3 feet in depth. Frequently on hills and on slopes near stream courses, the rock is either exposed or covered with a few inches of soil usually

mixed with cherty limestone fragments. Southeast of Barneveld, in the vicinity of Barber, the rock gathered from the fields is sufficient to build some fences. Although Dodgeville silt loam resembles closely Marshall silt loam, it is because of this shallowness, and apparent lack of transported material, or loess that the type is considered separately.

Extent and distribution.—This type of soil occupies the upland prairie sections of the eastern portion of the county, and consists of high plains and ridges. No area of the type is found below 1,000 feet elevation. It extends east from Dodgeville across the county on what is known as Military Ridge. Its continuity, however, is broken at Ridgeway, where a strip of Knox silt loam cuts through. It will be noticed from the map that the Chicago & North Western Railway forms a fairly good boundary for the type. A strip extends south from Dodgeville, and broadens out east of Mineral Point, where it continues southward into Lafayette County.

Topography and drainage.—The surface is undulating to gently rolling, and rarely hilly, while some of the broader areas are nearly level. The type has good natural drainage, and there is little or no need for artificial drainage anywhere.

Origin.—In origin Dodgeville silt loam is essentially a residual soil, derived chiefly from the decay of limestone. It is possible that there is incorporated with it a small amount of loess, which occurs chiefly as a thin covering over the residual material. The dark color of the surface soil indicates the presence of organic matter—the accumulation from the decay of prairie grasses, which formed the chief original vegetation.

Native vegetation.—This type embraces a portion of the prairie region of Iowa county and has never supported a forest growth. The native vegetation consisted chiefly of prairie grasses, with only a limited tree growth along the borders of the prairie and adjacent to stream courses.

Agricultural development.—The thinness and stony character of portions of this type have effected the kind of farm-

ing adapted to and developed in this part of the county. South and southwest of West Blue Mound the prairie type is 4 or 5 miles wide north and south. Here the thinness of the soil has rendered it susceptible to drought, and corn and the cereals are not as sure or as profitable crops as they are on the Marshall silt loam type. Much land is devoted to pasture, and dairying seems to be the type of farming best adapted to this part of the county.

There has been great improvement in buildings and in general prosperity in this section since dairying was introduced. Creameries and cheese factories are much more numerous here than on the Marshall silt loam type in the western part of the county. American cheddar and some Swiss cheese are manufactured. The product is shipped largely to Chicago, St. Louis, and other large centers. Many farmers make butter, which for the most part is consumed in the locality where it is produced. Few farmers ship cream or milk. Dairy herds consist of 15 to 40 cows. Corn is grown for fodder and silage purposes largely. Alfalfa has been successfully grown by some farmers and this crop will be more widely utilized in the future. Some difficulty has been experienced in securing a good growth of clover, owing to unfavorable weather conditions in winter and early spring.

The following table gives the average results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Dodgeville silt loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil.	0.0	0.3	0.7	0.9	14.7	59.5	23.7
Subsoil.	.0	.1	.1	.4	2.6	68.7	28.1

METHODS OF IMPROVEMENT FOR MARSHALL AND DODGEVILLE SILT LOAMS.

The areas of these soils, while differing somewhat in topography, are quite similar in chemical composition. Their analysis indicates between 1,300 and 1,400 pounds of phosphorus, 35,000 pounds of potassium, and 5,000 pounds of nitrogen in the surface 8 inches per acre. Their relatively large amount of nitrogen is due to the larger accumulation of organic matter which has taken place in these soils, due to their being in prairie rather than timber condition. It is probable that this organic matter has also tended to increase the phosphorus above that found in the Knox silt loam type. When first broken these soils showed a very high degree of fertility, and do still, except where poor systems of farming have caused the reduction of the active organic matter in the soil. In such cases even though the soil remains quite dark and has a good total supply of organic matter, this is in a resistant form in which it has been left by the oxidation of the more active vegetable matter.

The improvement of these lands demands an increase of active organic matter through the use of green manuring crops, particularly legumes, or large quantities of manure, as in the case of Knox silt loam. Owing to the fact that these soils, for the most part, occupy the higher areas of the ridge section of the county, they are less likely to receive lime in water percolating down from higher lands than in the case of the Knox soils; and for this reason, as well as on account of their larger amount of organic matter, show more or less acidity. This, however, is quite variable, and it is important that each farmer make the determination for acidity on each field. Where an acid condition is found to exist, ground limestone should be applied at the rate of from 1500 to 2000 pounds per acre.

On both of these types the dairy industry could well be developed to a greater extent. The supply of stable manure thus provided should be supplemented by green manuring crops, chiefly legumes, so that the supply of humus forming

material and active organic matter may be increased, and the productivity of the soil increased. Alfalfa should be grown to a greater extent, and the silo should be in more common use.

While neither of these soils have as large a percentage of steep lands as the areas of Knox silt loam, there are, nevertheless, some slopes on which erosion will take place unless the fields are properly handled. Wherever there is danger from erosion, the same means may be used for preventing washing as suggested for Knox silt loam.

CHAPTER III.

GROUP OF DARK COLORED BOTTOM SOILS.

WABASH SILT LOAM.*

Description.—The surface soil of this type, a depth of from 14 to 18 inches, consists of a brown to nearly black loam, which becomes quite silty in places. It is underlain to a depth of 36 inches or more by a black silty loam. Both soil and subsoil are subject to considerable variation, and there are no uniform areas of any considerable size. In places this type of soil contains a large amount of organic matter and is mucky; while in other places sand, gravel, and stones from the steep slopes adjoining have been washed down and have become mixed with the soil.

Extent and distribution.—Wabash silt loam is found as narrow strips of low land along most of the stream courses throughout the upland portion of the county. It varies in width from a few rods to nearly one-half mile. It has a total area in the county of 36,288 acres.

Topography and drainage.—The surface of this type is low and flat, usually having a gentle slope toward the stream along which it occurs. The type is subject to overflow, and the natural drainage is poor. Over the higher portions, some crops can be successfully grown, though there is always the possibility of losing a part or all of the crop as a result of high water.

Origin.—The material forming this type has been washed down from the higher land adjoining, carried varying distances by the streams and flood waters, and again deposited.

* In the future soil of this character will be classed as Wabash loam.

The loess-like material and also the weathered sandstone and limestone have contributed to the formation of the type.

Native vegetation.—the original growth consisted cheifly of willows, some ash, soft maple, and marsh grasses. A considerable portion of the type never supported a tree growth on account of the wet condition, but over such places a rank growth of coarse water-loving grasses was found.

Agricultural development.†—Much of this type of soil has poor drainage, and almost all of it is subject to one or more overflows each year and consequently can not be depended upon for cultivation. It is used almost exclusively for pasture and hay land, for which it is especially valuable. Occasionally a fairly well drained patch is cropped, corn doing especially well on it, and yields of 75 to 90 bushels per acre being reported. Hay will yield from 2 to 3 tons per acre. Owing to the narrowness of most of the areas and the low position of the land, it is doubtful if much of this type could be successively drained. Some of the broader expanses, where there is sufficient slope, could be much improved by installing tile drains.

WABASH LOAM.*

Description.—The surface soil of this type to a depth of 14 to 18 inches consists of a dark brown to black heavy loam or silt loam. The surface soil contains a large amount of organic matter and has a friable structure. The subsoil consists of a light-brown, or yellowish-brown, heavy loam, which usually grades into a silt loam below 24 inches. The silty material forming the type usually rests upon sand which may be reached at from 2 to 8 feet below the surface. In a few places of limited extent the underlying sand comes within a foot of the surface.

Extent and distribution.—The area of Waubash loam is of limited extent, and comprises a total area of only 4,160 acres.

† For methods of improvement of Wabash silt loam see page 30.
* In the future soil of this character will be classed as Wabash silt loam.

The largest tract in the county is found at the mouth of Underwood Creek directly west of Avoca. Along the bluff the silty material forming the soil in this area is from 5 to 8 feet deep, while along the border toward the Wisconsin River, it is frequently less than a foot deep. Other areas of smaller extent occur near Arena at the mouth of Rays Valley and Blue Mound Creek Valley. Some soil of this type occurs also along Sneed and Wyoming Creeks.

Topography and drainage.—The surface of Wabash loam is level or has a very gentle slope toward the stream along which it occurs. The portion of this type of soil in the Wisconsin River Valley near Avoca is higher and better drained than the remainder of the Wabash loam, and is not subject to overflow. Elsewhere, however, this soil is subject to overflow, and while it escapes flooding some years, there is always danger of having the crops damaged by high water. On the lower portions of soil of the type, the natural drainage is poor, and tile drains are necessary.

Origin.—The material forming Wabash loam soil has been washed from the higher land adjoining, and has been deposited by streams during times of high water. It is partly alluvial and partly colluvial, and the weathered material from the sandstone, limestone, and the loess have all contributed to its formation. Loess, however, has doubtless entered most largely into its composition.

Native vegetation.—The original growth consisted chiefly of willows, ash, soft maple, with numerous, open, wet tracts where only marsh grasses grew. The best drained tracts have all been cleared and put under cultivation.

Agricultural development.—This soil is very productive, yielding 60 to 90 bushels of corn, 25 to 50 bushels of barley and oats, and 1½ to 3 tons of hay per acre. Parts of it are subject to overflow, though not to the great detriment of crops.

In Wyoming, Hillside, and Blue Mound Creek Valleys this type requires drainage. It is very productive, but is apt here

to be a rather cold, late soil in wet years, though its natural drainage is slowly improving. Small grains, especially oats, produce rank straw growth, and are apt to lodge badly.

METHODS OF IMPROVEMENT FOR WABASH SILT LOAM AND WABASH LOAM.

These two types of soil have been formed largely by the deposition of silt from higher regions, and their chemical composition is determined by this. They have, on the average, approximately 2,000 pounds of phosphorus, 35,000 pounds of potash, and 5,500 pounds of nitrogen in the surface 8 inches of an acre. They are, therefore, among the richest soils of the state, so far as their chemical composition is concerned. During this process of formation a large part of the lime of the subsoil from which the Wabash silt loam and loam were derived was washed out, and the soils are, therefore, only moderately well supplied with this element, and will frequently be found slightly acid, so that for the continuous growth of clover, or alfalfa, it is desirable that tests be made for acidity. Where an acid condition is found to exist, from 1200 to 2000 pounds of ground limestone per acre should be applied.

The question of drainage is very important, and over a considerable proportion of the area of both of these types tile drains could be installed to advantage. It is probable that in a few places small dikes could be constructed to advantage, to protect the fields from flooding during times of heavy rains. Considerable damage is frequently done by erosion, especially in the narrow bottoms where the current during flood stages is swift. It is a difficult matter to prevent such erosion. Low walls are sometimes built,and brush and stones thrown into the channels to check the flow. Where there is an abrupt drop of several feet in the bed of the channel, a chute of boards is sometimes made to keep the channel from being cut deeper, and to prevent the sides from caving.

CHAPTER IV.

GROUP OF SANDY SOILS.

PLAINFIELD SAND.

Description.—Plainfield sand of this county is a loose brown sand of medium texture for 18 to 20 inches in depth. Below this it becomes lighter in color, till at about 30 inches it is a bright yellow sand, continuing without change to undetermined depths. The deposit has been found in wells to a depth of 50 feet. Frequently in the subsoil there is found a small percentage of smooth rounded pebbles mixed with the sand. In the subsoil, below 3 feet, layers of compact material a few inches thick are found, but these are seldom sufficient to affect moisture conditions.

The loose, incoherent nature of the sand renders it specially subject to drifting, and scattered through the areas are ridges piled up by the wind, which are mapped separately and discussed under the head of Dunesand.

Extent and Distribution.—Plainfield sand is confined to the Wisconsin River Valley along the northern boundary of the county. It occupies much of the valley bottom near the river, areas of meadow generally intervening between it and the stream. It is of comparatively small extent and occupies 9,920 acres, or 2 per cent of the total area.

Topography and Drainage.—The surface of Plainfield sand is level, and, owing to its looseness and depth, it usually has good drainage, the water table being 3 to 10 feet below the surface. South of the railroad, between Helena and Arena, water is occasionally found within 3 feet, and in a few places the surface is so wet as to approximate a marshy condition. In general, a

lack of moisture is apparent in the type and crops suffer from drought during portions of practically every growing season.

Origin.—Plainfield sand consists of stratified material which has been deposited during overflow of the river, probably during one of the glacial epochs when the volume of the water was considerably greater than at present. The coarseness of the sand, and lack of material finer than sand, is due to deposition in relatively swift currents.

Native vegetation.—The areas covered by Plainfield sand are locally spoken of as prairie land. The only tree growth which the type supported was a very sparse scattering of scrub oak. Wild grasses and sand burs constitute the greater portion of the native vegetation.

*Agricultural development.**—Only limited number of crops are grown on this Plainfield sand. These are corn, rye, and buckwheat. Rye succeeds best, though the yield is low. In a good year corn yields 25 bushels per acre; in dry seasons it is a complete failure. The yield of rye is 10 to 15 bushels, and of buckwheat 5 to 20 bushels per acre. Oats and barley have not been successful on this type of soil. It is very difficult to make improved grasses and clover profitable crops. Rye follows corn and is often sown on the stubble among the corn shocks. To lessen blowing by the wind, the surface is left rough and ridged as much as possible, as wind-blown areas are very difficult to control.

PLAINFIELD SANDY LOAM.

Description.—Plainfield sandy loam is a brown sandy loam, 16 to 18 inches deep, resting on a subsoil which becomes lighter in color and a little lighter in texture with depth, and passes usually at about 30 inches into a yellowish sand. The lower part of the soil section thus resembles that of the Plainfield sand. As the soil proper is more loamy, and has more body than the Plainfield sand, there is not much trouble from drift-

* For methods of improvement for Plainfield sand see page ——.

ing with this type. There have been included with Plainfield sandy loam, certain small areas, which, had they become more extensive, would have been mapped as a separate type. The soil in these areas is more loamy and sometimes quite heavy, though the soil is generally sandy. Most of this phase is found in the areas west of Avoca and at the mouth of Mill Creek Valley.

Extent and distribution.—Like Plainfield sand in this county, Plainfield sandy loam is confined to the Wisconsin River Valley. It is found in large areas more often nearer the bluffs of the uplands than the river. The largest area occurs in the immediate vicinity of Arena, where it extends for a distance of nearly eight miles as a narrow belt between the foot of the bluffs and the areas of Plainfield sand and marsh, bordering the river. In the northwestern part of the county near Avoca, the areas of this soil are rather small and detached, while farther east the tracts are larger. The total area of this soil in Iowa county is 4,864 acres.

Topography and drainage.—The surface of areas of Plainfield sandy loam is quite uniform, being nearly level. In parts of sections 12, 13, and 14, R. 5, T. 8, there is a plateau-like area, considerably above the level of the rest of the type. As a rule the type has good drainage. Crops sometimes suffer from drought during the latter part of the growing season.

Origin.—This soil is of alluvial origin and has been formed in the same manner as Plainfield sand. Its more loamy character is evidently due to the fact that deposition has taken place at some distance from the river, where the velocity of the currents were less than where the Plainfield sand was laid down. In places the upland streams undoubtedly have contributed some finer material in times of overflow.

Native vegetation.—It is said that this type of soil formerly had a sparse tree growth consisting of oak and soft maple, and considerable brush. The sand bur is a characteristic plant, as it is on the Plainfield sand.

*Agricultural development.**—Almost all crops grown locally succeed well on Plainfield sandy loam, although on much of the type in years of less than normal rainfall crops are likely to suffer from drought. Corn yields vary from 35 to 70 bushels, with an average of probably 45 bushels per acre. Oats are not a sure crop, but yield about 20 bushels in normal seasons, though in years of more than average precipitation yields as high as 30 to 35 bushels may be secured. Barley is seldom grown. Rye produces from 12 to 20 bushels with an average of about 15 bushels per acre. The yield of hay is not large, probably about 1 ton to the acre. Not much trouble is experienced in getting a catch crop of clover, and it will generally grow satisfactorily.

This type of soil is generally considered fairly desirable land, and the farms composed of it are usually in a prosperous condition. Dairying is important, though the farmers do not always depend entirely on this type of soil for pasture. Some farms on this type include areas of the Wabash soils or Knox silt loam, and these afford good pastures.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Plainfield sandy loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0.5	8.2	37.4	38.4	1.7	9.6	4.0
Subsoil	.3	7.5	41.8	41.0	1.3	4.0	3.8

BOONE FINE SANDY LOAM.

Description.—Boone fine sandy loam consists of a brown or light brown fine sandy loam to a depth of 8 to 10 inches. This is underlain by a fine sandy loam of about the same texture, but somewhat more compact, and also lighter in color. This material usually grades into a fine sand, which is found immed-

* For methods of improvement for Plainfield sandy loam see page 37.

iately overlying the sandstone rock from which the soil is derived. The type is subject to considerable variation both in texture and topography, though none of the variations were found to be of sufficient extent to be indicated on the soil map. The type frequently contains considerable silt which has been washed from the Knox silt loam, with which it is associated; and in such places this soil is heavier than typical. In other small areas there are patches of fine sand. In a few localities the type consists of a medium sandy loam. The soil is frequently shallow, and rock outcrops are quite common. Rock fragments may also occur throughout the surface soil, in places.

Extent and distribution.—Boone fine sandy loam is of comparatively small extent in area and occupies a total space of only 5,440 acres. The type is found principally in the bluff country in the vicinity of the Wisconsin River where Potsdam sandstone outcrops along the slopes. A few small patches occur in the southwestern portion of the area where St. Peters sandstone outcrops.

Topography and drainage.—The surface of the soil of this type varies from gently undulating over small tracts along the lower slopes and at the foot of the bluffs, to steep and rather broken land along the hillsides and ridges. On most of the area of Boone fine sandy loam, modern farm machinery could be used. The areas which are too steep are of comparatively small extent.

On account of the sandy nature of the soil and the topography of the region, the natural drainage is excellent. Where the soil material is thin, the type is subject to drought.

Origin.—This soil type comprises chiefly material resulting from the weathering of Potsdam sandstone, though there are a few places in the southwestern portion of the area where St. Peters sandstone has contributed to its formation. The lower lying tracts are also partly colluvial, and it is probable that the silt found in the soil has come largely from the loessial material forming the Knox silt loam.

Native vegetation.—The original timber growth on Boone fine sandy loam consisted chiefly of white, burr, and black oaks, with some hickory, maple, birch, and basswood. Practically all of the merchantable timber has been removed, and most of the type is under cultivation. On the steeper slope there is still a growth of timber, but it has little value.

*Agricultural development**.—Boone fine sandy loam is in general considered a fairly productive soil, but in dry years, crops are apt to suffer from drought, and particularly so on the ridges, where it is often thin and rather stony. Good crops are raised where the soil has sufficient depth and is properly managed, particularly with reference to conservation of moisture. It has the advantage as compared with the heavier silty soils in the ease with which it can be worked, and the early date at which it can be plowed in the spring. The relatively small extent and irregular distribution of this type make it unlikely that any single farm is composed entirely of it. It thus varies the soil conditions on many farms. On the better phases of the type good corn, grain, clover, and mixed hay are produced, with yields only slightly lower than those stated for Knox silt loam.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Boone fine sandy loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0.0	6.1	16.6	39.5	11.8	19.0	7.1
Subsoil	.0	3.2	9.6	30.0	15.6	28.0	13.5

DUNESAND.

Dunesand includes the light colored fine sand which has been blown into dunes by the wind. This soil is loose and open in

* For methods of improvement of Boone sandy loam see page 37.

structure and uniform in texture, throughout its occurrence. There is but very little organic matter in the surface, and no clay or silt particles are present to bind the sand grains together. The dunes are from 10 to 12 feet high, cover tracts of from 1 to 150 acres, and occur as small knolls and ridges with shallow intervening depressions. This Dunesand is found in the northern part of the county, in the valley of the Wisconsin River, where it is associated with Plainfield sand and sandy loam. The natural drainage is excessive, and the type is very droughty.

The material composing the Dunesand is of alluvial origin, but has been blown into knolls and ridges by the wind. When not protected by growing plants, the dunes are modified constantly by the action of the wind. Over portions of the dunes there is a scattering growth of scrub oak, and in some places there is a little grass, but most of the knolls and ridges are bare.

This type has very little value and may be considered non-agricultural. Where covered with trees, sometimes it serves as a wind brake for farm buildings; but where bare the dunes are a menace to surrounding fields, as high winds drift the sand quite rapidly, and adjoining crops may be badly injured by the fine, sharp particles. The sites of some of the dunes were formerly tracts of Plainfield sand or sandy loam, but the wind has brought many of these areas beyond control.

METHODS OF IMPROVEMENT FOR PLAINFIEID SAND, PLAINFIELD SANDY LOAM, BOONE FINE SANDY LOAM, AND DUNESAND*.

These types of soil have the chemical composition usually found in the sandy soils of Wisconsin. They have, on the average, approximately 1,000 pounds of phosphorus, 20,000 pounds of potassium, and from 1,000 to 2,000 pounds of nitrogen in the surface 8 inches of an acre. Their relatively small amount of organic matter, however, does not make even these quantities of the mineral elements, phosphorus and potassium,

* See Bulletin 204, University of Wisconsin Experiment Station, on "Improvement of Sandy Soils" and No. 230 on "Soil Acidity and Liming".

sufficiently available, so that methods of adding organic matter and nitrogen, chiefly through the growth of legumes, should be the starting point in their improvement. As a rule these soils will be found at least slightly acid, so that the use of some form of lime for clover and alfalfa is important, though some other legumes which do not require lime can be grown. Applications of from 1,500 to 2,000 pounds of ground limestone per acre will usually be found sufficient to correct the acidity.

In starting clover on these sandy soils, it is advisable to seed without a nurse crop, especially where the fertility is very low. In preparing the soil it should be plowed in the fall, or as early in the spring as possible, and a top dressing of ground limestone applied. The field should be harrowed at short intervals until about the middle of May, when about 15 pounds of seed per acre should be sown and covered to a depth of 2 to 2½ inches. The seeding should be followed by a roller to compact the soil around the seed, and the roller should be followed by a light harrow to roughen and loosen the surface, to check evaporation and blowing of sand by the wind. Where it can be secured, a top dressing of well rotted manure should be applied before the last harrowing. Where manure is not available about 300 pounds of acid phosphate, or ground, steamed bonemeal and 100 pounds of muriate of potash should be applied at the time of seeding. If only a small amount of manure is available it may be supplemented by ground rock phosphate, and this can be sprinkled over the manure in the spreader and applied at the same time. The second year the first crop of clover may be cut for hay, but the second should be plowed under as green manure to prepare the soil for cultivated crop.

Alfalfa may be started in the same way, only the soil should be inoculated with earth from an old alfalfa field. If for any reason the clover or alfalfa should fail, a crop of spring vetch, tare, soybeans, cowpeas, yellow lupine, or serradella may be grown as a green manuring crop, and plowed under. A rotation consisting of clover, potatoes, and rye or oats is one well suited to sandy soils. If a green manuring crop is plowed un-

der once during each rotation, and as much manure applied as the farm supplies, the soil can be maintained in a fairly good state of fertility.

Where the sand is apt to be blown by the wind the fields should be laid out in long narrow strips at right angles to the direction of the prevailing wind and cultivated strips should alternate with strips in grain or grass.

It will be very difficult and probably impracticable to raise crops on the Dunesand, but it would be desirable to have the dunes covered with some plant which would tend to check the blowing of the sand by the wind.

CHAPTER V.

GROUP OF MISCELLANEOUS SOILS.

LINTONIA SILT LOAM

Description.—The surface soil of the Lintonia silt loam type, extending to an average depth of 14 inches, consists of a light brown, or grayish, silt loam, having a friable structure, and containing only a small amount of organic matter. The subsoil consists of a light brown to yellowish brown silt loam, which gradually becomes heavier with depth and grades into a silty clay loam, or clay loam, at from 24 to 36 inches. In texture, structure, and color Lintonia silt loam is very similar to Knox silt loam, but differs from that type in topography and origin.

Extent and distribution.—Lintonia silt loam is of limited extent, occupying only 2,368 acres, or about 5 per cent. of the county. It is confined to the northern part of the county, and is found most extensively along Otter creek and Blue Mound creek, where it occurs in terraces of from 50 to 200 acres in extent.

Topography and drainage.—The surface of the type is nearly level with only a gentle slope toward the stream course along which it occurs. In some places of limited extent ravines have been cut through the terraces, and the surface made somewhat irregular and dissected by erosion. As this type of soil is usually well elevated above the present stream level, the natural drainage is good. In only a few instances in this county would tile drains be necessary.

Origin.—Lintonia silt loam in Iowa Count is largely of alluvial origin, though there is also considerable colluvial ma-

terial which is incorporated with it. Most of the type was deposited by the streams along which it occurs during an earlier geological period. Streams have subsequently cut down into this material and built strips of low overflow land which has been mapped as Wabash loam and silt loam. Practically all of the material in this type of soil was originally loess. This was washed from the upland country into the lower land by heavy rains carried away by the streams, and again deposited in its present position.

Native vegetation.—The original timber growth consisted chiefly of oaks and hickory, with some maple and basswood. Most of the timber has been removed, and the land put under cultivation.

Agricultural development.—Lintonia silt loam is a desirable soil, and all of it is available for cultivation. Its level surface makes washing a minor factor. The surface also favors the use of all kinds of labor-saving farm implements. In crop value the type is probably superior to Knox silt loam, especially for corn. Those areas mapped in Blue Mound Creek valley generally are more productive and compare well with Wabash loam. Where this type is well elevated and has good drainage, it seems to be adapted to alfalfa.

Methods of improvement.—The chemical analysis of Lintonia silt loam shows it to contain, on the average, slightly more of most of the essential plant food elements than occur in Knox silt loam which it very much resembles in texture, structure, and color. In the improvement and management of this type the suggestions offered for the Knox silt loam will also apply here, except as regards erosion.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Litonia silt loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0.0	0.2	0.4	1.0	13.2	73.6	11.2
Subsoil	.0	.0	.0	1.5	7.6	78.8	12.2

MUCK.

Description.—The type of soil mapped as Muck consists of decaying vegetable matter which is usually quite thoroughly decomposed, and with which there is incorporated a considerable amount of mineral matter. This soil is quite variable, however, and in places will be a Peat, while in other localities the Muck will have occasional bars of sand running through it. It has a dark brown or black color and ranges in depth from 2 to 20 feet, or more.

Extent and distribution.—The area of Muck is of comparatively small extent and occupies a total space of 2,432 acres. The largest body is a marshy tract bordering the river, northeast of Arena. It covers about 2 square miles and is about 2 to 4 feet above the level of Blue Mound creek. In Blue Mound Creek Valley there is an area of about 300 acres which is being tile drained. There is also a small tract at the mouth of Otter creek. This area has a thin covering of silty material, but it is too low to be drained successfully by gravity ditches.

Topography and drainage.—The surface of all the areas of Muck is level, and the natural drainage is deficient. Before crops other than wild hay can be grown, it will be necessary to install drainage systems. Over portions of the Muck this could be done profitably, while in other places it would not be practicable.

Origin.—In origin the Muck of this region consists of a mixture of decaying vegetable matter and mineral matter which

has been washed in from the higher land adjoining. In the Wisconsin River Valley it is usually underlain by stratified sand, while in the other stream valleys silt, and sometimes some clay, is found beneath it.

Native vegetation.—Most of the Muck areas are open marshes with only a rank growth of coarse grasses, but over a portion of the marshes there are a few willows, soft maple, and some other moisture-loving trees and shrubs.

Method of improvement.—Only a single analysis of the Muck from this county has so far been made, but this indicates approximately similar composition to that found in Peat soils of the Wisconsin River Valley farther north. These soils have an entirely different chemical composition from other, more earthy soils. They are extremely rich in organic matter and nitrogen, having from 8,000 to 12,000 pounds of nitrogen as compared with 2,500 pounds in the silt loam soils of the hill county to the south. They are, however, poorer in phosphorus and potassium than other soils are, and the availability of these elements is frequently quite low. Where the farm contains upland soils as well as marsh soil, manure should be applied to the upland soil which needs the nitrogen as well as the other elements, and commercial fertilizers containing only phosphorus and potash should be used on the marsh soils, since they will give nearly, if not quite, as good results as the manure will, on account of their very large supply of nitrogen. These soils are usually acid, but it is not necessary to neutralize the acidity by the use of lime, since ordinarily medium red clover and alfalfa would not be grown on these lands.

Drainage is the most important step in reclaiming the Muck areas, and, wherever this is practicable, drainage systems should be installed. The area in Blue Mound Creek Valley which is being drained will doubtless produce good crops, especially corn. Other tracts could also be reclaimed, but at present most of the areas are used only for cutting marsh hay and some for pasture.

MEADOW

Meadow comprises the low-lying, marshy areas immediately adjoining the Wisconsin River. These areas alternate in places with small tracts of Plainfield sand which could not be separated. The Meadow and Muck taken together cover a considerable proportion of the valley bottom.

The largest area of Meadow lies in the northwest corner of the county, where it covers 5 or 6 square miles. The soil material varies from deposits of white to yellowish, coarse sand and mottled, silty clay, deposited by the annual spring floods, to patches of mucky material too small to show on the map. Here and there are sloughs and wet spots which persist even in times of low water. The Meadow is sometimes wooded, though the greater portion of it has very few trees, as is the case north of Avoca.

This type, while unfit for cropping, serves as much needed pasture and hay land for the farmers living on Plainfield sand, which supports but a sparse growth of grass. Hay is brought up on the terrace of Plainfield sand and stacked there in dry weather.

Owing to its low-lying position, it is doubtful if any system of drainage would avail much, though open ditches would often give some relief. The soil is, therefore not very valuable for agriculture.

ROUGH STONY LAND.

Rough stony land consists of rock exposures, cliffs, and steep, precipitous land too rough to plow or cultivate profitably. It occurs largely along ravines and valleys within the main body of the Knox silt loam, practically none of it having been mapped within or adjacent to the Dodgeville or Marshall silt loams. Comparatively little of it occurs in the southern part of the county, but it is quite extensive in the northern part.

A large part of the rough stony land is covered with oaks, hickory, and some maple, though it is often cleared and used for pasture. Occasional patches too small to show on the map

FIG. 3. CHARACTERISTIC VIEW OF ROUGH STONY LAND.

This type includes rock outcrop, and steep rocky slopes which have but little or no agricultural value, and may be considered as non-agricultural.

WISCONSIN GEOL. AND NAT. HIST. SURVEY. PLATE II

FIG. 4. VIEW FROM THE HEAD OF A SMALL VALLEY, LOOKING TOWARD THE WISCONSIN RIVER.

This shows the steep rocky valley wall on the right which makes up part of the Rough stony land, and the lower slope upon which some of the steep phase of Knox silt loam may be found.

are cultivated. Where there are a few inches of soil it is usually silty, being the same material as Knox silt loam. Sandstone outcrops on many of the slopes, and the soil near by is likely to be sandy as a result of the disintegration of this rock.

Owing to the steep, rugged character of this type, its use is confined to pasture. It is largely allowed to remain in forest.

CHAPTER VI.

GENERAL AGRICULTURE OF IOWA COUNTY.

The agriculture of Iowa county dates back about 80 years. Lead had been mined in the county by the Winnebago Indians for some time prior to this, and most of the early settlers were drawn hither by rumors of rich deposits of ore. The first recorded attempt at farming was in 1829, when 40 acres of land in the town of Linden, in the west-central part of the county, were put under the plow. In the same year farms were opened in the town of Dodgeville. The first crops of wheat and oats in the county were produced on the farm at Linden in 1831 from seed secured in Illinois. A grist mill was established in 1830, 2 miles northeast of the present site of Mineral Point. Here small grain was ground into feed, and corn into meal; but flour was brought by team from Galena, Ill.

Wheat early became the most important crop, and it soon gave rise to an improvident system of farming, this crop being grown year after year, until the yields declined to a point where the profits were extremely small. The timber from the cleared lands was wasted and burned, because there were no sawmills in the interior of the county, and no good means of transportation to the river. Practically the only source of income on the farms was from the sale of wheat. In parts of the county much of the wheat land was later put into flax, until it also began to fail. The continued cropping of the land to wheat and flax caused it to become gradually less productive, and made it necessary to adopt a type of farming more profitable, and tending less to deteriorate the soil. This necessarily led to stock raising and dairying. With the advent of this change, 30 years ago, agriculture became more diversi-

fied, and farmers began to handle their soils more rationally and to put more manure on the land.

Where this better treatment has been intelligently carried out, the soils have gradually regained much of their original productiveness. This change was especially needed on Knox silt loam, which naturally has less organic matter than Dodgeville and Marshall silt loams or prairie, and which, owing to steeper topography, was subject to much erosion under the old type of farming. Most farmers now recognize that it is not advisable to plow the steeper phase of this type, but to allow such land to remain in pasture as long as possible. Iowa county is, now, distinctly a dairy county.

The United States census of 1910 gives the area devoted to wheat during the previous year as 1,111 acres, which produced 20,132 bushels or an average of 18 bushels per acre. The high tide in the production of wheat was about 1870 when the production was 760,165 bushels for the county.

The yield of corn for 1909 from 38,148 acres amounted to 1,272,498 bushels or an average of about 33.3 bushels per acre. The total production of corn and the average yields for this county have remained nearly stationary for the past 30 years.

The production of oats was not nearly as large for 1909 as was reported by the state census for 1905, though the difference may be due in part to unfavorable weather conditions during the latter year, rather than to a tendency to gradually reduce the acreage devoted to this crop. The yield from 41,433 acres in 1909 amounted to 1,314,454 bushels or about 31.7 bushels per acre, while the report of 1905 showed an acreage of 69,581 acres, with an average yield of about 30.4 bushels per acre.

The acreage of barley for 1909 was 9,812 acres, and the total yield 259,881 bushels, or an average yield of 26.4 bushels per acre. This is over 6,000 acres more than was reported for 1905.

With the decline in the production of wheat, beginning about 1870, flax growing increased until about 1880, when the yield for the county was 120,061 bushels. Since that time flax production has greatly declined, and in 1905 there were only

211 bushels reported. At present the crop is not grown at all on a commercial scale.

Rye is grown more extensively in the northern and eastern parts of the county than elsewhere, and the total yield of the county from 4,374 acres in 1909 was 43,700 bushels, or an average of about 10 bushels per acre. Buckwheat is comparatively unimportant. Tobacco was raised to some extent 25 years ago, but none is grown now. Potatoes never have been grown on a large commercial scale, but a sufficient amount is produced for home use. In 1909 there were 1,250 acres which produced a total yield of 137,044 bushels or approximately 109 bushels per acre. The small acreage is partly due to the fact that the prairie soils are somewhat heavy for potato growing, and also to the fact that much of Knox silt loam is steep and subject to erosion, which makes the growing of cultivated crops undesirable. These conditions will prevent Iowa county from ever becoming an important potato growing region. However, on the more level portions of Knox silt loam and over portions of the prairie soils, conditions are favorable to the production of more potatoes than are grown at present.

The hay crop of Iowa county for 1909 from 69,012 acres amounted to 95,127 tons, or nearly 1.4 tons per acre. Of this the major portion consisted of mixed timothy and clover. Over 26,000 acres of timothy alone were grown, but the amount of clover alone grown was less than 1,000 acres. Alfalfa is grown to a limited extent, and the acreage is gradually on the increase. Small amounts of sorghum and millet are also raised.

The trucking industry has not been developed in Iowa county on a commercial scale, though every farm has a home garden where small fruits and vegetables are grown for the use of the family. Sometimes there are small quantities of truck sold on the local markets.

But little attention is paid to fruit growing. Only small home orchards are found, and apples are practically the only fruit raised. Little or no care is taken as regards pruning, spraying, cultivation, etc. Soil of the Knox silt loam type is probably more favorably located for general fruit growing than soils of Marshall or Dodgeville silt loams, chiefly on ac-

count of the more desirable slopes which afford excellent orchard sites. The growing of apples could well be extended on this soil. Peaches do not succeed, as they are very apt to winter kill.

Dairying is the most important branch of agriculture practiced in the county, and this industry has reached extensive proportions. The production of cheese far exceeds that of butter. No milk is shipped out of the county as market milk. In 1905 there were 105 cheese factories, which produced 5,732,843 pounds of cheese; and in 1910 there were 128 factories, which produced 7,412,286 pounds of cheese. In 1905 there were 12 creameries, which produced 829,250 pounds of butter; and in 1910 there were only 6 creameries, with a total output of 513,577 pounds. As a matter of convenience some farmers prefer to patronize creameries rather than cheese factories, where milk has to be delivered daily, because they can separate the cream at home and deliver on alternate days, and have skim milk for calves and pigs. Butter production, however, is not apt to increase, as long as the price of cheese remains relatively higher than that of butter.

The character and breeding of dairy cattle is gradually receiving more attention. The first cattle kept were the native red cattle, and grade stock probably still predominates. The Holstein-Friesian breed is held in high favor, and there are more pure-breds of this breed in the county than of any other. In 1905 there were 29,605 milch cows in the county. This was an increase of 18% in 10 years, and of 60% in 25 years. In 1910 there were 34,559 milch cows. Out of every 100 head of cattle there are at the rate of 45.8 milch cows.

The raising of steers and beef cattle is not so prominent as it was a few years ago, though it is still important. Occasionally steers are brought from Chicago or other points to be fattened, and home grown stock is also finished for the market. This industry, however, has gradually declined as the dairy industry has developed. Hog raising is important, and it has gradually developed along with dairying. Poland-China seems to be the predominant breed, although there are also numerous herds of Duroc-Jerseys and Chester Whites.

The raising of sheep is not given much attention, and the number kept is gradually decreasing. In the northern half, and over all the rougher parts of the county, this industry might well be extended, since the steep slopes are better fitted for grazing than for cultivated crops, and since there is more of such land than is required for the number of cattle kept at present.

The question of crop rotation is given some consideration, and it is quite generally recognized that certain soils of the county are better adapted to some of the crops grown than are other soils. The methods of farming followed, therefore, differ slightly on the various soil types, and especially where there is a wide difference in the texture of the types. The predominant class of soil in the area is a silt loam, and while there are some variations in the methods followed throughout the silt loam regions, it may be said that in general the methods are quite uniform. The degree of slope, and the danger of erosion, is a factor which causes some modification in the usual methods followed.

Marshall silt loam, because of its level topography, high organic matter content, and greater depth, produces good crops of corn year after year without washing and without material decline in yield where fields are manured. For this reason the fattening of hogs and cattle is more extensively carried on in the west prairie section of the county, and cheese factories and creameries are least numerous there. In the eastern part of the county Dodgeville silt loam, as well as Knox silt loam in the northern part of the county, is much thinner; and the present prosperous conditions are due in large part to the growth of dairying in the last few years.

Knox silt loam almost invariably lies at such a slope that much of it washes badly during hard storms. Very little of it should be put into cultivated crops, two years in succession. Farmers state that, while the yield in bushels of oats and barley is much the same in these two soils, the grain on the Knox silt loam is heavier and of better quality. Better pasture is, also, claimed for the latter soil.

When sufficiently drained Wabash soils produce corn fully as

well as the Marshall silt loam. Especially good crops are raised on them in dry, early seasons. Grain, especially oats, is likely to lodge badly, and an excessive growth of straw is produced. The Wabash loam gives good yields of alsike and white clover. These soils are seldom acid, and alfalfa may be grown on selected areas with little trouble in getting a catch.

The sand prairie of the Wisconsin Valley bottom is cropped only to rye, buckwheat, and corn. The sandy loams there produce fair clover and also grain crops.

On both Knox and Marshall silt loams corn is planted on newly turned sod which has been manured. It is grown one or two years, followed by oats or barley one year, and the land then seeded to timothy and clover, which is allowed to remain three or four years. If the seeding does not catch well, oats or barley is sown again. When wheat or rye is introduced it usually follows oats or barley.

On the loose Plainfield sand of the Wisconsin Valley, rye follows corn, and buckwheat is introduced as found most convenient.

Deep plowing and careful tillage are generally practiced for all crops. Corn, the principal intertilled crop, is well cultivated. It is usually planted with check-row planters. Before it is up, the fields are usually harrowed lightly, which forms a mulch and arrests the growth of weeds. When the crop is well up, wheeled two-horse cultivators are used until the corn is too large for cultivating. The ears are often husked from the standing stalks, though frequently the corn is cut, shocked, and later husked. The corn and barley are used chiefly for feed. Much of the oats and some of the rye are consumed in the county, but a number of thousands of bushels are exported annually.

Here, as in most parts of the country, labor is scarce and hard to obtain at any price. Most of the farm work, thus, has, to be performed by the farmer and his family. When men are employed by the month they usually receive from \$25 to \$30 and board. When employed by the day, they receive \$1.50 and board, and in harvesting from \$2.25 to \$2.50 and board.

About 78 per cent of the farms in the area in 1910 were operated by the owner; 14 per cent by cash tenants and approx-

imately 7 per cent by share tenants. The number of farms is gradually decreasing, and the average size increasing. In 1910 there were 1,965 farms containing on the average 185 acres per farm. Of this there is on the average 117 acres improved.

In general, the types of farming now established, and methods in common use seem well suited to the soils and present conditions in the county. Corn, the most important single crop of the county, could be materially increased in yield by more general attention to the selection and storage of seed.

Root crops for cattle feed and the use of silage should become more general as the dairying is increased. Alfalfa also should be more generally grown.

Alfalfa is not extensively grown in any part of the county, but has been tried with good success in small patches on Knox silt loam, Dodgeville and Marshall silt loams, Wabash loam, and to a slight extent on some of the better quality of sandy lands in the Wisconsin Valley. This crop ought to become more generally produced as farmers become acquainted with it. Excepting portions of the Wabash, the soils all have good surface and subsoil drainage. Knox silt loam in many places has not sufficient depth to make a desirable soil for alfalfa, but most of the type is amply sufficient as to depth. The following suggestions may be of use in growing this crop:

A deep soil, and one in a good state of fertility, with plenty of organic matter, is needed to start a good growth of alfalfa. In many places Knox, Dodgeville, and Marshall soils have become acid, through lack of proper cropping.

From 1,200 to 1,500 pounds of ground limestone applied to land previously well manured, and followed by thorough cultivation should produce a good seed bed for alfalfa on any of these soils. Inoculation will usually be found unnecessary if a pint of alfalfa seed be sown to the acre with cloves during the rotation previous to which alfalfa is seeded.

Wabash soils are not often acid, though they contain large quantities of organic matter. Lack of drainage is apt to be their only deficiency for alfalfa production. Where this crop is sown, a field with a distinct slope is desirable. Several good pieces of alfalfa seeding were noted on Wabash loam where no attempt at inoculation was made.

CHAPTER VII.

CLIMATE.*

Among the factors which influence the agriculture of a state, none is more important than the climate. The class of crops which can be grown is largely determined by the length of the growing season, and the amount and distribution of the rainfall. Any one of these factors may determine the type of agriculture which can be practiced to best advantage.

The distribution of rainfall over Wisconsin is remarkably uniform, the average yearly precipitation having a range of from 28 to 34 inches, while the mean for the State as a whole is 31 inches. This is a slightly heavier rainfall than is received by eastern England, northern France, most of Germany and Sweden, and the Dundee Valley. As compared with other portions of this country, Wisconsin has a total rainfall equaling that of central Oklahoma and Kansas, northern Iowa, Michigan, northwestern New York, or the Puget Sound Basin of Washington. But owing to its northerly location, the lessened evaporation probably makes the precipitation as effective as that of Arkansas, Illinois, or Virginia.

The local distribution of rainfall varies, however, from year to year, some sections receiving more rainfall one year and other sections more in other years. The variation is caused by the movement of cyclonic storms. The average rainfall for the entire state during the driest year was 21.4 inches. and for the wettest year 37 inches.

Of equal importance, in agriculture, to the total rainfall is its seasonal distribution, and in this respect Wisconsin is un-

* This chapter has been taken largely from Wisconsin Bulletin 223, on "The Climate of Wisconsin and Its Relation to Agriculture". This bulletin should be consulted for more information on climate.

usually fortunate, since about half of the total rainfall comes in May, June, July, and August, and nearly 70% from April to September, inclusive. June has the heaviest rainfall, averaging 4.1 inches, while July averages 4 inches and May 3.9 inches. The precipitation during the winter, on the other hand is slight; December, January, and February each averaging from 1 to 1.5 inches of rain and melted snow. The average rainfall for the state during the winter is 3.9 inches, during spring 8.3 inches, during summer 11.4 inches and during autumn 7.4 inches. Most of the rainfall occurs just preceeding and during the period of plant growth, thus being received by the crop at the most effective time. Wisconsin receives during the growing season, April to September, inclusive, an average of 21 inches, which is as much rain as is received during the same months by eastern Texas, Illinois, Ohio, or eastern New York. The small winter precipitation in Wisconsin, mostly in the form of snow, on the other hand, causes virtually no leaching of fertility from the soil, or erosion.

Another phase of rainfall distribution of great importance is its variation within a period of a few weeks. Frequently periods of drought and periods of unusually heavy rainfall occur, continuing for from one to four weeks, and occasionally longer. Observations taken at Madison over a period of 30 years, from 1882–1911, inclusive, show that there are, on the average, three ten day periods during each growing season when the amount of rainfall is so slight that crops on a reasonably heavy soil (Miami silt loam) actually suffer from the lack of moisture. In Iowa County, where the predominant soil is a silt loam, the conditions would doubtless be practically the same, for the area as a whole.

Iowa County lies within "the Southern Highlands", which is one of eight climatic sections within Wisconsin.

"This possibly new term is used to include the rough to rolling region, generally over 1000 feet in elevation extending from Clark county south to the Illinois line and lying between the Mississippi Valley on the west and the Wisconsin and Rock River Valleys on the east. It is characterized by a cooler temperature than the adjoining valleys, the summer tempera-

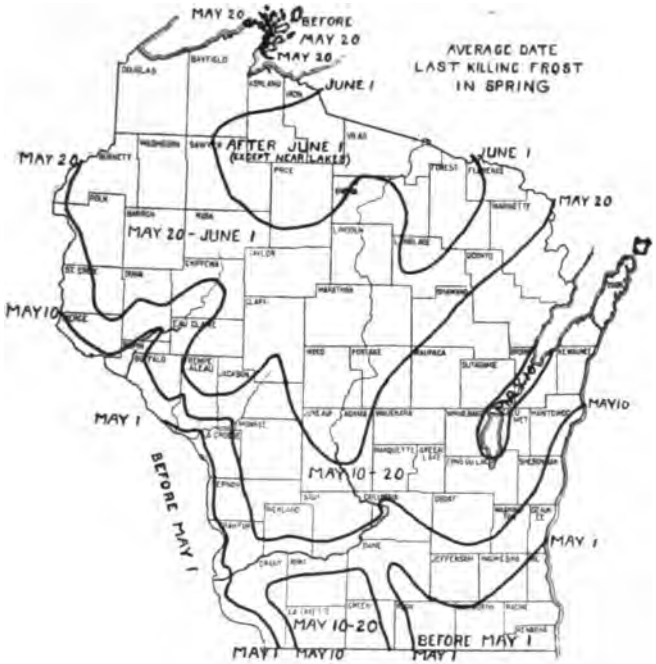

Fig. 5. Last Killing Frost in Spring.

Fig. 6. First Killing Frost in Fall.

These maps have been prepared from the original monthly reports of the observers of the U. S. Weather Bureau for the past 12 years, supplemented by private records.

ture (66° to 69°) being similar to that along the Michigan shore, while the mean winter temperature is only about 2° higher than along the Superior shore. The growing season, averaging 145 days, is apparently twenty to thirty days shorter than the lower lands of the state in the same latitude, while in the river valleys and ravines in this section, the frost danger is still greater, the combined records at Darlington and Gratiot (in LaFayette Co.,) averaging only 120 days. Corn in exceptional years fails to mature, while grass and hay are the dominant crops. The use of land for pasturage is also encouraged by the topography and the heavier rainfall (averaging 34 inches.)"

By reference to figures 5 and 6, it will be observed that the average date of the last killing frost in the spring in the region including Iowa County is from May 1 to 10 in the northern part of the county along the Wisconsin River, and from May 10 to 20 in the southern part of the area, where the elevation is greater. The average date of the first killing frost in the fall in the same region is from Oct. 1 to 10 in the northern part, and from Sept. 20 to 30 in the southern part. From the data on these two maps the approximate length of the growing season for any part of the state can be readily determined.

No weather records extending over a long periol are available for points in Iowa County, but at Lancaster, about 15 miles west of the southwestern corner of the county, weather observations have been made covering a period from January 1, 1893, to December 31, 1903. The following table has been compiled from these records, and as the elevation of the station is 1,100 feet, the conditions are similar to those existing over most of Iowa County:

Normal monthly, seasonal, and annual temperature and precipitation at Lancaster.

Month.	Temperature.			Precipitation.			
	Mean.	Mean highest monthly.	Mean lowest monthly.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.
December	20	27	13	1.2	1.2	0.2	6.7
January	17	22	3	1.2	.7	.9	8.7
February	15	22	9	1.1	1.1	1.1	8.8
Winter	17	....	....	3.5	3.0	2.2	24.2
March	31	38	22	1.6	2.8	2.0	6.7
April	48	52	42	3.2	1.1	3.6	1.1
May	60	65	55	3.9	2.9	2.7	....
Spring	46	....	....	8.7	6.8	8.3	7.8
June	68	71	63	3.6	1.3	1.5	....
July	72	80	70	4.5	1.6	9.4	....
August	70	75	66	2.4	.6	4.0	....
Summer	70	....	....	10.5	3.5	14.9	....
September	61	68	56	3.3	3.3	4.8	....
October	50	57	41	2.2	3.3	3.6	Trace.
November	32	41	28	1.5	1.3	1.8	4.5
Fall	48	....	....	7.0	7.9	10.2	4.5
Year	45	....	....	29.7	21.2	35.6	36.5

Average date of last killing frost in spring, May 8: and of first in fall; Sept. 29.

From this table it will be seen that the annual rainfall for this station averaged 29.7 inches, and that the average for the driest year is 21.2 inches. These data indicate that the precipitation is comparatively uniform and ordinarily sufficient for agriculture. The mean annual temperature is 45°, with a winter mean of 17° and a summer mean of 70° F. The average length of the growing season at this station is 143 days. From this table, and from the other records given, it will be

observed that there is considerable variation as to the occurrence of killing frosts within this portion of the state, depending largely upon the elevation.

SUMMARY

Iowa County, with an area of 754 square miles, is situated in the driftless area in southwestern Wisconsin.

The topography is that of an elevated to rolling plain in the middle of the county, becoming slightly hilly and rougher to the south; and deeply cut on the north, becoming rougher as the Wisconsin River is approached.

The drainage eventually reaches the Mississippi River, either by way of the Wisconsin and its tributaries on the north, or the Pecatonica to the south.

Four railroad lines traverse portions of the county, giving good transportation facilities.

The population of the county is 22,497 (1910), or 30 people to the square mile. It is well distributed over the entire county.

The soils are residual, loessial, and alluvial, the last lying along small streams and in the Wisconsin Valley. Thirteen types of soil are shown on the soil map.

Knox silt loam occupies about 51.3 per cent of the area of the county. It is especially subject to erosion when put into cultivated crops. It is well adapted to pasture, grain growing, and the dairy type of farming. This land sells at $35 to $100 an acre, depending upon the amount of rough land included.

Marshall silt loam is a prairie soil, especially adapted to corn growing, and live stock and dairy interests. There is very little rough land in this type, and it sells for $60 to $100, or more, an acre.

Dodgeville silt loam is not so well adapted to the cereals as Marshall silt loam, and is principally devoted to pasture and the growth of silage crops. Dairying is well developed on this type, butter, cream, and cheese being produced.

Boone fine sandy loam is of small extent and is found mainly along the bluffs of the Wisconsin River and tributaries, with a few smaller areas along the Pecatonica, in the southwestern part of the county. It produces good corn, small grain, and hay crops.

Wabash silt loam is an alluvial soil, often poorly drained and found in the smaller valleys and stream courses. The soil is variable: small portions are mucky. It is mainly used for pasture, though more elevated areas give good corn and hay crops.

Wabash loam is more uniform than the silt loam, is somewhat better drained, and is found in the wider stream bottoms and as an outwash deposit over the Wisconsin Valley sands. It is a very productive soil, usually benefited by tile drainage. It often produces 90 bushels of corn per acre, and sells at $70 to $100 or more an acre.

Plainfield sand occupies a large proportion of the Wisconsin Valley bottom. It is not a very valuable soil and is inclined to be droughty. It gives fair crops of corn, barley, and buckwheat in favorable years.

Plainfield sandy loam is the better type of sandy soil of the Wisconsin Valley bottom. It produces good grain crops and clover will grow on it.

Dunesand consists of irregular, generally small, areas of Plainfield sand which has been blown into ridges by the wind. This is hardly an agricultural soil: it is very poor and is generally kept wooded.

Lintonia silt loam is an alluvial soil found on elevated, well-drained, and level terraces along the sides of the larger stream bottoms entering the Wisconsin River Valley. It resembles Knox silt loam in texture and is slightly higher in agricultural value.

Muck is found closely associated with Meadow. In some of the larger stream bottoms some of it can be readily and profitably drained.

Meadow includes the marshy portions of the Wisconsin Valley adjoining the river. Part of it is wooded and part is clear and furnishes pasture and good crops of marsh hay.

Rough stony land consists of rocky cliffs and steep, stony hill land too rough to plow. It is found mostly within Knox silt loam type in the northern half of the county. Much of it is useful for pasture and forestry.

Agriculture dates back to 1830, wheat being the first important crop. With the decline of wheat production about 1870, dairy and live-stock interests developed. The county is now distinctly a dairy section. Corn is an important crop. Cheese, cattle, and hogs are important products. Lead and zinc are mined in the southern and western parts of the county. Alfalfa, root crops, and silage should come into more general use as dairying develops. About 78 per cent of the farms are operated by owners.

The climate is healthful, and the rainfall generally sufficient for all crops.

KEEP THE MAP.

The Experiment Station will publish bulletins from time to time dealing with the management of the different types of soil mapped, so that some way should be found by each person receiving a copy of this report to keep the map permanently. If the map is folded in such a way as to have the part you are interested in of a convenient size and then have a simple frame with glass made to hold it, it can be kept indefinitely. Since some of the colors fade after being exposed to strong light for a long time, it would be a good plan to have a protecting flap of dark cloth over the map when not in use.

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

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SOIL SURVEY IN COOPERATION WITH THE COLLEGE OF AGRICULTURE, H. L. RUSSELL, DEAN.

BULLETIN NO. XXXI SOIL SERIES NO. 5

SOIL SURVEY

OF THE

BAYFIELD AREA

WISCONSIN

BY

A. R. WHITSON, W. J. GEIB, L. R. [illegible]NMANN AND F. L. MUSBACK

OF THE

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

AND

GUSTAVUS B. MAYNADIER

OF THE

UNITED STATES DEPARTMENT OF AGRICULTURE

SURVEY CONDUCTED IN COOPERATION WITH THE UNITED STATES DEPARTMENT OF AGRICULTURE, BUREAU OF SOILS, MILTON WHITNEY, CHIEF. CURTIS F. MARBUT, IN CHARGE, SOIL SURVEY

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INTRODUCTION

Before the greatest success in agriculture can be reached, it is necessary that the farmer should have a thorough knowledge of the soil upon his own farm. A soil may be well adapted to one crop, and poorly adapted to another crop. Clover will produce a vigorous growth and profitable yields on the average loam soil which contains lime and is in a sweet condition; but on a sandy soil which is sour, or in an acid condition, clover will not make a satisfactory growth. We may say, therefore, that failure is certain to be invited when such important facts are disregarded, or overlooked. The degree of success which it is possible to win on any farm is in direct proportion to the practical knowledge possessed by the farmer concerning the soil and its adaptation to crops. A thorough knowledge of the soil is as essential to the farmer as a knowledge of merchandise and business methods is to the merchant.

The State of Wisconsin, working in coöperation with the United States Department of Agriculture, is making a careful study of soils and agricultural conditions throughout Wisconsin, and is preparing soil maps and soil reports of all counties in the State. A soil map shows the location and extent of the different kinds of soil. Tracts of 10 acres and over are mapped, but often areas of even smaller extent are shown. The soil map is prepared by trained men, who go over a county thoroughly, and examine the soil by making a sufficient number of borings to a depth of 36 inches to keep account of all variations. A report is also made, to accompany and explain the map, and this is based upon a careful study of the soils within the region surveyed, and upon such other features as have a direct bearing upon the agriculture of the area.

It is the object of this survey to make an inventory of the

soils of the State, and to be of practical help to farmers by locating and describing the different soils, by determining their physical character and chemical composition, and by offering suggestions for their management, based upon the work of the Soil Survey within the area, covered in the report, and upon the results of field tests made by the Experiment Station.

Soil fertility depends upon two factors: first, upon the physical characteristics of the soil, such as water holding capacity, workability, etc., and second, upon the chemical composition of the material composing the soil. The chemical composition depends upon the mode of origin of the soil, and the source of material from which the soil is derived.

Water holding capacity, and other physical properties of soil all depend chiefly upon *texture*, which refers to the size of the individual soil grains, or particles. A coarse sandy soil, for example, will not retain moisture so long as a loam soil, or clay loam, because the finer the soil grains, the greater will be the total soil-grain surface area to which moisture may adhere. Texture is determined in the field by rubbing the soil between the thumb and fingers, and with experience one soon becomes expert at judging the size of soil grains. This field judgment is verified in the laboratory by a *mechanical analysis*, which is made by a simple method of separating soil grains into different groups, of which there are seven. These are known as clay, silt, very fine sand, fine sand, medium sand, coarse sand, and fine gravel.

A chemical analysis is also made of the soil to determine the amounts of various essential plant-food elements which are present. A chemical analysis shows whether the soil contains a large store of plant food, or only a small quantity, and it indicates which kinds of plant food will probably be needed first. The amount of organic matter in the soil is also determined, and tests are made to show conditions relative to soil acidity.

SOIL CLASSIFICATION.

Soils are grouped according to texture into soil classes, a *soil class* being made up of soils having the same texture, though differing in other respects. A fine sand, for example, may be light colored and of alluvial origin, while another fine sand may be dark in color and of residual origin, while a third fine sand may have been blown into sand dumes by the wind, yet all of these soils would belong to the same class, because the greater proportion of the soil grains have the same size or texture. Thus we may have different kinds of clays, loams, sands, etc., and the class to which any soil will belong depends upon the size of the individual soil grains of which it is composed, and not upon its color, origin, topographic position, or agricultural value.

SOIL CLASSES

Soils Containing Less Than 20% Silt and Clay

Coarse sand.—Over 25% fine gravel and coarse sand, and less than 50% of any other grade of sand.
Sand.—Over 25% fine gravel, coarse and medium sand, and less than 50% fine sand.
Fine sand.—Over 50% fine sand, or less than 25% fine gravel, coarse and medium sand.
Very fine sand.—Over 50% very fine sand.

Soils Containing Between 20–50% of Silt and Clay

Sandy loam.—Over 25% fine gravel, coarse and medium sand.
Fine sandy loam.—Over 50% fine sand, or less than 25% fine gravel, coarse and medium sand.
Sandy clay.—Less than 20% silt.

Soils Containing over 50% of Silt and Clay

Loam.—Less than 20% clay, and less than 50% silt.
Silt loam.—Less than 20% clay, and over 50% silt.
Clay loam.—Between 20 and 30% clay, and less than 50% silt.
Silty clay loam.—Between 20 and 30% clay, and over 50% silt.
Clay.—Over 30% clay.

Soils may be grouped in another way. Where soils are closely related through similar sources of the material from which derived, mode of origin, topographic position, etc., so that the different soils constitute merely a graduation in texture of otherwise uniform material, such a group is called a ***soil series.*** It corresponds to the family which is made up of different individuals having the same parentage. The Miami series, for examples, includes light colored, glacial material where the soils

have been derived largely from the underlying limestone, and the soils in the series range in texture from a clay loam to sand and gravel. The Plainfield series includes light colored soils in regions where no limestone is present, and where the material occurs as outwash plains or stream terraces. The soils in this series also have a wide range in texture. The name used for a soil series usually indicates the locality where that particular series was first recognized and mapped by the Soil Survey.

By uniting the name of the *soil class,* which refers to texture, with the name of the *soil series,* which refers chiefly to origin, we get the *soil type,* which is the basis or unit of classifying and mapping soils. A *soil type,* thus, is a soil which is uniform throughout its entire extent in texture, color, topographic position, and other physical properties, and having a distinct agricultural unity, that is, being adapted to the same crops, and requiring the same treatment. It is also uniform in the source of material from which it is derived, and the mode of origin which, taken together, determine the chemical composition. Since the soil type is the unit in classifying and mapping soils, and the basis upon which experimental work should be conducted, every farmer should be familiar with the soil types on his farm, and their leading characteristics.

SOIL SURVEY OF THE BAYFIELD AREA, WISCONSIN

CHAPTER I.

GENERAL DESCRIPTION OF THE AREA.

The Bayfield area, covering 329 square miles, or 210,560 acres, includes portions of Bayfield and Ashland Counties, Wisconsin. It covers that part of Bayfield County lying east of the ninety-first meridian of longitude and north of 46° 30′ north latitude, together with that part of Ashland County included in Tps. 47 and 48, R. 4 W. on the mainland and the entire group of the Apostle Islands. This area is situated in the extreme northern part of the State, close to the western extremity of Lake Superior; and the surveyed portion of the Bayfield Peninsula, together with the adjacent islands, constitutes the most northerly land in Wisconsin.

In the region comprising this area and the adjacent country were the earliest white settlements in this section, exploration parties under Radisson and Groseilliers having visited it as early as 1661. Trading posts were early established to facilitate intercourse with the Indians at various points in this region, one of which, on the shores of Chequamegon Bay, was called La Pointe. This post, subsequently removed from te mainland to Madeline Island and familiarly known as the Old Mission, has become famous by its association with the memories of Allouez and Marquette. The agricultural development of this country until very recently has, however, been slow, notwithstanding the fact of its early exploration. The great wealth of its forests, which first attracted attention, and the subsequent discovery of the mineral resources of northern

Wisconsin were the inducements that brought about most of the development which has taken place. This whole region was originally peopled by the various branches of the Chippewa Indian Nations, which are now represented by but few individuals.

The earliest white immigration was from other portions of the then Northwest Territory, of which this region was a part, and from Canada, the latter settlers being mainly of French extraction. More recently the immigrants have been largely Scandinavians and Germans.

That portion of the Bayfield Peninsula included within this area is of a rolling and almost rugged character, possessing but a few level areas, none of which are of any great extent. It is a region of hills and valleys. The slopes of the former, however, are seldom steep enough to prevent cultivation, though in some of the latter the drainage is inadequate. The elevations rise at once from the shore line on the east in a sharp, terracelike ascent, while on the north the shore line is characterized by a continuous line of precipitous bluffs of red sandstone or red clay from 10 to 50 feet in height, from which the rise is very sharp, elevations of 200 and even 300 feet being found at distances of from a few hundred feet to about a mile from the shore line in the northern portion of the peninsula. Proceeding southward the shore line loses much of its ruggedness, and the land along the shore assumes a more gently rolling character, that bordering on Chequamegon Bay on the south being low and level for a considerable distance inland. That part of Ashland County located on the mainland and included in this area lies mainly to the south of the city of Ashland. It extends from the lake front in a series of gentle rises and level stretches, reaching its maximum elevation in the southeastern part of the area, and forming a gently rolling plain somewhat dissected by depressed streams and gullies.

The surface features of the Apostle Islands are somewhat varied. The shore line of practically all of them consists of bluffs from 20 to 100 feet high, with here and there a few sand beaches, from which there is a gradual rise toward the cen-

ter. Stockton, Ironwood, Michigan, Cat, and Sand Islands are somewhat saucer shaped, their interiors being slightly depressed or at least nearly flat. The topography is usually gently rolling, or has a gradual slope from the bluffs along the lake to the interior. Oak Island is the highest and most rugged, reaching an elevation of 420 feet above the lake. This is higher than any part of the mainland within a few miles of the lake shore. The elevation of the other islands ranges from 20 to 150 feet above the lake.

In the northern part of the Bayfield Peninsula, numbers of small streams, together with Sand and Raspberry Rivers, afford an excellent system of surface drainage for much of this country. In areas of Superior clay considerable erosion has taken place along these stream courses. The sandy loam, however, permitting the passage of the water downward, rather than tending to create surface flow, is not so greatly affected. By reason of the rolling character of the surface, there are many depressions in this section in which the drainage from the adjoining hillsides collects, and from which it can escape but slowly, resulting in the formation of swampy spots. These are of frequent occurrence, but are usually of small individual extent. At present but little attempt has been made to drain the greater number of these areas, though as agricultural development progresses, they will doubtless all be reclaimed.

South of Ashland the slope is generally northeastward, the drainage being effected through the White River and other streams, into which many small streams find their way. Owing to its nearly level topography and to the impervious character of the soil and subsoil, much of the land lying south of the city is but poorly drained. The soil in this region is so retentive of moisture, and storm waters run off so slowly, that, as agriculture develops, it will be necessary to install drainage systems.

Until quite recently a large part of the area was a pinery of great value. White pine was the most valuable species found in the original forest, as well as one of the most abundant. Norway pine, hemlock, white and black spruces, balsam fir, white ce-

dar, and tamarack were also abundant. Deciduous and hardwood species were represented by birch, elm, oak, maple, basswood, aspen, hickory, and ash. Most of the available timber has been removed, and the areas of stump land are now overgrown with a dense seedling growth, consisting chiefly of birch and aspen. When the original growth of the valuable white pine was removed, no adult seed-producing trees were left standing; consequently there has been no reseeding. Had a sufficient number of trees been left for this purpose, there would now be a thrifty stand of young pines that in time would overcome the intruding birches and poplars and reclothe these lands with a forest as valuable as that which has been so destructively removed. Moreover, the conditions provided by the undergrowth of birch, poplar, and other deciduous species are admirably adapted to the protection of the tender evergreen seedlings.

A very small proportion of this area is cleared, the greater part being covered with the dense growth that sprang up when the timber was removed, and is still occupied by the stumps that mark the location of the former extensive forests. The cost of clearing and preparing these lands is considerable, yet the development that has taken place up to the present time indicates that satisfactory returns may be expected from capital judiciously invested in farming in this region.

Convenient transportation by rail and water puts all sections of this area in close communication with outside points as well as those places located within its limits. The Northern Pacific, Minneapolis, St. Paul & Sault Ste. Marie (Wisconsin Central), and Chicago & Northwestern Railway systems all enter this area, giving rapid transportation facilities to Duluth, St. Paul, Minneapolis, Milwaukee, and Chicago, as well as to the many smaller towns of the State and to the rapidly growing places in the iron and copper country. Besides the trains, daily boats ply between Ashland, Bayfield, and Washburn, and a ship-line connects Bayfield with Duluth, running three boats weekly each way.

The chief city of the area is Ashland, a place of about 12,000 population. It is the shipping point for large quantities of iron

ore and has ore and coal docks of great capacity. Here also are extensive lumber mills, a blast furnace, and a wood-alcohol works. It is supplied with electric lights and a street railway, and has waterworks and a sewerage system. There are churches of various denominations and many graded schools. The high school is an imposing building, said to be equal in both equipment and structure to any in the State. The city has wide streets, on which are located many good business blocks, banks, hotels, and residences.

Washburn, the next town in point of size, has a population of about 4,000. It is the county seat of Bayfield County, and is a brisk and thriving town, possessing good graded and high school buildings, numerous churches, a newspaper, banks, and retail business houses. Large sawmills and extensive lumber docks are located here. It is connected by rail and ferry with Ashland.

Bayfield has long been known as a resort for hay-fever sufferers, being one of the few places where victims of that malady are said to obtain immunity from their sufferings. It is a picturesquely located hillside town of about 2,000 population, situated near the northern end of the peninsula, directly overlooking the Apostle Islands. It has extensive lumber interests and sawmills. Many hundreds of tons of Lake Superior whitefish, trout, herring, etc., are shipped from this point annually. It is connected with points outside of the area by the Chicago & Northwestern Railway system, and by that route and by ferry with Ashland. Frequent communication is kept up with Madeline Island, 2 miles off the mainland, and others of the Apostle Islands. It has numerous graded schools, a fine high school, a public library, and churches of many denominations, as well as good retail stores, and banking and hotel facilities. Bayfield is the center of a highly promising fruit-raising section, and a large area of small fruits, apples, and cherries is being developed, the direct result of the highly satisfactory yields and quality of the products obtained in this vicinity.

SOILS.

The soils of the Bayfield area are of glacial and lacustrine origin. The glacial material consists of a heterogeneous mass of stones, sand, silt, and clay, and belongs to the Late Wisconsin stage of glaciation. This mass of material, forming the local soils of the present day, was brought into the area from the northeast over the country now occupied by Lake Superior. The depth of the loose material over the underlying rock varies greatly, ranging from a few feet to several hundred feet. The hills in the vicinity of Bayfield, as well as the Kettle Range, are largely derived from this drift. Since its deposition some erosion has taken place, serving to accentuate the rough topography prevailing over part of the area.

Coming from Canadian shores, as the glacier did, a part of the deposit, and especially the coarser particles, is very different from the rock on which it rests, and covers quite a wide range of mineralogical material. A considerable percentage of the drift, however, is of local origin and consists of the ground-up particles derived from the underlying red Potsdam sandstone. Many of the stones and bowlders of foreign origin are striated or scratched with deep grooves

The lacustrine material, or what might be more properly classed as glacio-lacustrine, was probably deposited prior to the advent and retreat of the Late Wisconsin glacier when the lake stood at a much higher level than at present. The beds of heavy red clay which were thus formed were later modified somewhat by the advance of the ice sheet. In places the clay was picked up by the ice or pushed along and mixed with the material already carried by the glacier. It is this modification by glacial action which accounts in part at least, for the presence of pebbles and some bowlders in the clay on the Bayfield Peninsula and in the vicinity of Washburn, for the more uneven topography in these localities, and also for the mixture of clay and sand which is found in some places as the subsoil of the Superior sandy loam. The level topography and the almost entire lack of pebbles and bowlders south of Ashland

indicates that the clay beds there were not influenced to so great an extent by glacial action.

As only a small proportion of the area is improved, and as most of the region is cut-over land covered with a dense second growth, fallen trees, brush and stumps, it is much more difficult to map than well settled regions. On account of these conditions it was found impracticable to separate and indicate all of the minor variations in the soil. The map is, therefore, somewhat more general than the detailed areas in the southern portion of the State.

The names of the several types of soil mapped in the area, together with their actual and relative extent, are given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Superior clay..........	112,576	53.4	Beach sand................	1,792	0.9
Superior sandy loam.......	81,344	38.6	Superior silt loam.........	1,472	.7
Coloma gravelly sand......	8,128	3.9	Genesee loam..............	320	.2
Marsh (containing areas of swamp)	4,928	2.3	Total..................	210,560	......

CHAPTER II.

GROUP OF CLAY AND SILT LOAM SOILS.

SUPERIOR CLAY.

Description.—This type of soil, one of the most extensive in the area, is a heavy, compact clay of pinkish-red to light chocolate red color, with no apparent difference in color or texture between the soil and subsoil. After being properly cultivated for a few years, the soil appears to become lighter in texture and looser in structure, and to approach a brown color. This is due to mellowing effect of cultivation and to the incorporation of organic matter. When wet it is very adhesive and plastic; in drying it cracks on the surface, and both soil and subsoil have a tendency to break into cubical blocks or grains.

The surface frequently has a covering of from 1 inch to 3 inches of grayish silty material, from which the clay particles have doubtless been removed, and with which are incorporated varying quantities of organic matter. In many places, however, this covering has been entirely eroded. Small areas of sand, forming a thin layer over the clay, are sometimes found, but areas of this character are usually of too limited extent to be indicted on the map. Small depressions or flat areas of poor drainage, locally known as swamps, are found. Most of these patches may be readily drained when cleared, and as the soil differs from the better-drained areas chiefly by having a higher organic matter content, and as the patches are of small extent, they have not been separated.

In both soil and subsoil are sometimes found fragments of rocks and rounded pebbles, with an occasional bowlder. These are most common in that portion of the type lying near Washburn and farther north on the Bayfield Peninsula, where the

clay is more closely associated with the moraine, and where it has been somewhat modified by glacial action. This modification doubtless accounts for the texture being slightly lighter in these localities than it is in the southern part of the area.

Extent and distribution.—This is the most extensive type in the area and occupies 53.4 percent of the region surveyed. Extending south from Ashland, and northward along the west shore of Chequamegon to a point about 6 miles north of Washburn, its extent is broken only by a few small patches of Superior sandy loam. The type is extensively found in the northern part of the Bayfield Peninsula also, and it occurs on some of the Apostle Islands. On Madeline and Sand Islands it is the predominating type.

Topography and drainage.—The surface of this type varies from level to gently rolling and even rolling in a few places. The level tracts are found chiefly in the region west and south of Ashland. As found on the Bayfield Peninsula the surface is frequently more rolling. The rolling phase is not as extensive nor as important as the level portion of the type. Superior clay is very retentive of moisture, and the impervious character of the subsoil, together with its generally level topography, makes the problem of drainage a highly important one. Much of the type in this area, in its natural condition, is very deficient in this respect, and its surroundings are such as to present difficulties in establishing an adequate drainage system. Tiles are found to work well, notwithstanding the seemingly impervious nature of the subsoil. Reliance is at present chiefly put in open ditches, so arranged as to remove quickly the surface water, and but little tile draining has been done in this area. Experience has shown the system of shallow surface drains to be very effective, and since such drains can be readily and cheaply constructed, they are recommended for general use at the present time. On the level tracts tile drains are necessary, and on some of the gently rolling or sloping land, though not absolutely essential, they are beneficial. Where the farms are more highly developed and the financial condition of the

landowners will permit, tile drains should be installed where drainage is the most deficient.

Origin.—The type is a lacustrine deposit laid down probably prior to the Lake Wisconsin stage of glaciation and later influenced in varying degrees by the ice sheet. In this area it occurs chiefly on the nearly level plains in the southern part and as a more rolling bench along a portion of the northern and eastern shore line. On some of the islands and in the northern portion of the area, its position on the slopes seems to indicate that it was at one time overlain by a covering of the sandy material now found on the higher elevations, but which has since been removed. This type is highly susceptible to stream erosion, and when found occupying even slightly rolling plains, it has frequently become deeply gullied along the stream courses.

Native vegetation.—The original growth of white pine and other conifers in the south half of the area has been entirely removed, and on the uncultivated portions of the type in this region there has sprung up a thrifty growth of aspen and poplar. In the northern part of the area on the Bayfield Peninsula there is considerable hardwood, chiefly maple, birch, and hemlock, and some of this is still in virgin forest.

Present agricultural development.—Where favorably located, Superior clay is a strong soil and is eminently suited to the production of grasses and clover for mowing as well as for pasturage. Potatoes, mangels, turnips, and corn are being grown with success. Early varieties of corn for silage can be grown on all of the type. Some corn has been matured, and very satisfactory yields secured. Peas do very well, and yields of 33 bushels per acre have been secured. Wheat has yielded from 25 to 32 bushels per acre on the Experiment Station farm, and potatoes average 150 bushels, with a maximum yield of 320 bushels per acre. While good yields of potatoes are secured, the soil is heavy and rather difficult to handle for this crop. Clover does very well, and some alfalfa has been successfully grown on well-drained areas of small extent.

After a few years of proper cultivation, especially when clover is grown, this soil becomes much more loamy and more

FIG. 1. VIEW OF SUPERIOR CLAY SOUTH OF ASHLAND, SHOWING CHARACTERISTIC TOPOGRAPHY.

The natural drainage of the Superior clay is deficient. This field has been seeded, and shallow open ditches have been constructed to assist in carrying off the surface water.

WISCONSIN GEOL. AND NAT. HIST. SURVEY. PLATE I.

FIG. 2. VIEW OF SUPERIOR CLAY WHERE THE LAND HAS BEEN TILED.

The drainage of the Superior clay improves the physical character of the soil, and insures larger yields. This field of barley shows a thrifty, vigorous growth, and the stand is uniform.

easily worked. The type is well adapted to general farming and dairying, and development is now well under way along these lines, especially in the vicinity of Ashland and southwest of Washburn.

*Methods of improvement.**—The chemical composition of Superior clay shows it to have considerable amounts of most of the essential elements of soil fertility. It is only moderately well supplied with phosphorus, however, and where heavy crops are produced and especially where grain or hay is sold from the farm and comparatively little concentrated feed stuff purchased, it will be found profitable to use commercial fertilizers containing this element. The total amount of potassium is large, as is the case with all members of the Superior series of soils. The total amounts of organic matter and nitrogen are only fair and should be increased. The surface soil is often more or less acid, but the subsoil is well supplied with lime, so that while moderate applications of some form of lime may be necessary on much of this type of soil to permit clover and alfalfa to make their best growth, it is very probable that when alfalfa is well established and drawing on the subsoil, much less lime will be needed than on the more acid sandy soils.

In order to render this type more open and porous, and better to effect the ventilation and aeration of it, the use of coarse stable manure or the plowing under of green manuring crops is to be recommended. Wherever such a course has been followed a marked improvement has resulted in every instance. Good crops of wheat, peas, turnips, rutabagas, and potatoes have been obtained in the second year following such treatment. The question of drainage† should be given careful consideration. While tile drainage is not essential, except in a few instances, it is very desirable, even where there is a gentle slope.

From the results obtained on the Experiment Station farm near Ashland, it appears that the best way to subdue and improve this type is to practice thorough cultivation and to follow

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* See Wisconsin Bulletin 202, The Management of Heavy Clay Soils.
† See Wisconsin Bulletin 329—The Right Drain for the Right Place.

a definite crop rotation, plowing under a crop of clover occasionally. A rotation which has given good results consists of small grain—wheat, rye, oats, or barley—the first year, seeded with clover and a little timothy; the second year clover, the first cutting being for hay and the second left for seed; the third year, mixed clover and timothy. The sod is manured either before plowing in the fall, or on the plowed field during the winter. The fourth year a cultivated crop should be grown.

Uncleared, cut-over land of this type can be bought for $12 to $25 an acre. Farms of similar soil, cultivated and improved, in Fond du Lac County can not be bought for less than $100 an acre.

The following table shows the average results of mechanical analyses of the Superior clay, both soil and subsoil:

Mechanical analyses of Superior clay.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent	*Per cent*	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0.6	2.8	4.7	11.6	12.6	31.3	36.4
Subsoil	.9	3.9	6.0	13.9	14.2	29.8	31.3

SUPERIOR SILT LOAM.

Description.—Superior silt loam, to a depth of about 12 inches, consists of a reddish or chocolate colored, very fine sandy or silt loam, underlain by silt or very fine sandy loam. But little difference in color exists between soil and subsoil, which latter merges at an increasing depth into stiff red or brown clay. This type is recognized solely by the percentage of silt present in both soil and subsoil, and by the absence of rock fragments and gravel so commonly met with in Superior clay.

Extent and distribution.—The type is of limited extent, occupying only .7 per cent. of the area, or approximately 1,472

acres. It is confined to a few small scattered acreas in the northern part of the Bayfield Peninsula.

Topography and drainage.—The surface of the type varies from nearly level over small tracts to gently rolling and rolling. Over the more level portions the natural drainage is deficient, and tile drains should be installed before the best results can be expected.

Origin.—This type is a lacustrine deposit of glacial material, but has been considerably reworked. It occupies an intermediate elevation between Superior clay and Superior sandy loam. The depth to which its surface and intermediate layers have been laid down over the red clay is extremely variable.

Native vegetation.—The original timber growth of hemlock, spruce, and pine has been nearly all removed and is now succeeded by gray birch and popular.

Present agricultural development.—Only a small proportion of Superior silt loam is under cultivation but from results thus far obtained the type has proven to be a good general farming soil, and when improved will be adapted to the same crops as Superior clay. It is a lighter soil, however, and can be cultivated with less difficulty. It may also be adapted to a wider range of crops.

Methods of improvement.—The chemical composition of Superior silt loam does not vary largely from that of the Superior clay as given on page 21. In most cases it has a somewhat higher amount of organic matter and also has a somewhat larger amount of lime in the subsoil, though the surface soil is in many cases slightly acid. Its improvement in fertility should be along the lines suggested for the management of Superior clay as stated on page 21.

Like Superior clay, its most profitabe use would probably be in connection with dairying as pasture or mowing lands for the production of hay, both grass and clover doing well on it. By applying stable manure or by having green crops plowed under to supply organic matter so much needed by this type, marked increases in these crops will be obtained. Such treatment also is necessary if root crops of any kind are

to be grown on it. On one farm in the area it has been recently planted to strawberries, but it is too soon to determine its fitness for their production.

The following table gives the results of mechanical analyses of soil and subsoil of Superior silt loam:

Mechanical analysis of Superior silt loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0.4	0.9	0.8	2.0	1.6	82.1	12.2
Subsoil	.0	.0	.0	1.0	4.6	67.1	27.4

CHAPTER III.

GROUP OF SANDY SOILS.*

SUPERIOR SANDY LOAM

Description.—Where typically developed the surface soil of Superior sandy loam, to a depth of 12 to 18 inches,. consists of a gray to brownish sand or light sandy loam of fine to medium texture, usually becoming somewhat loamy with increased depth. At 18 to 24 inches it passes into a stiff, tenacious red clay. Occasionally at the lower depths the clay subsoil is interstratified with layers of fine sand and pockets of sand are sometimes found. The subsoil is the same material as the Superior clay, and where exposed in road cuts or by stream erosion, it exhibits the same tendency to break up into cubical particles and to crack and check. A characteristic of the type is the presence on the surface of rounded stones and bowlders, the latter in places in such quantities as to interfere with cultivation.

Areas of this type, as described, occur in the vicinity of Bayfield and along the north shore of the Bayfield Peninsula. The greater proportion of the soil on the Apostle Islands is also typical. There are, however, areas of considerable extent on the mainland, where the soil varies considerably from the description given above. The most important difference is that the clay subsoil is not always within 3 feet of the surface, and in a number of places it undoubtedly lies more than 6 feet below the surface. The surface soil in such places consists of a medium to fine loamy sand, which usualy grades into a loose, incoherent yellow or brownish sand of medium texture. A small quantity of gravel is sometimes found upon

* See Wisconsin Bulletin 204—"The Improvement of Sandy Soils."

the surface and also in the lower subsoil. On account of the irregularity of these variations, the fact that the clay may be found coming to the surface in places throughout the deep sand areas, and considering that the country is largely undeveloped cut-over land, thickly grown up with brush which makes it very difficult to get over, separation of the several types could not be satisfactorily made.

Superior sandy loam is confined chiefly to the north half of the area and to the Apostle Islands, though there are a few scattered areas in the southern part of the survey.

It is the second type in the survey from the standpoint of acreage and comprises 38.6 per cent. of the area surveyed.

In topography this type is gently rolling to hilly. On some of the islands and also on a portion of the mainland it occupies gentle slopes, but much of it is steep, though never too steep to be cultivated or put in orchards.

On account of its topography and texture, the natural drainage is good. Where the clay subsoil lies at considerable depth below the surface, crops may suffer from lack of moisture during extended dry spells.

In origin the material composing Superior sandy loam is derived from two sources. The sand, gravel, and bowlders are all of glacial origin, while the underlying clay is lacustrine material which has been influenced more or less by glacial action.

The original timber growth consisted of pine, hemlock, maple, birch, and spruce. All of the pine and the best of the other timber has been removed. The second growth consists chiefly of birch and poplar. The clearing of the underbrush and the removal of the stumps is a difficult task and requires a great deal of labor. The cost of clearing and getting the land ready for the plow varies from $30 to $75 an acre.

Present agricultural development.—Only a comparatively small percentage of Superior sandy loam is under cultivation. As a rule it possesses good surface and internal drainage, is easily tilled, and is warm, responsive soil. It is the predominance of this type in the vicinity of Bayfield that has earned for that place its reputation as a fruit-producing center.

VIEW OF SUPERIOR SANDY LOAM, FOUR MILES WEST OF WASHBURN, SHOWING CHARACTERISTIC SURFACE FEATURES.

Fruit growing has developed to a greater extent on this type of soil than on any other in the Bayfield area. This cherry orchard was planted on new ground, and while the trees are young, other profitable crops are being grown on the same field.

Superior sandy loam is especially adapted to the production of small fruit and truck crops. Apples and cherries also do well when the location is suitable. Good crops of clover, timothy, potatoes, peas, and root crops are obtained. Corn for silage can be readily grown and some has been matured. Alfalfa has been successfully grown. The greatest returns from this type are secured from strawberries and bush fruits which come on the market after berries from other sections are gone and when there is a good demand.

In view of its adaptation to a wide range of crops and the fact that it warms up more rapidly in the spring than the heavier soils, this type is probably the most valuable in the area.

Method of improvement.—The chemical analysis of Superior sandy loam shows that the heavy subsoil is essentially the same in chemical character as that of Superior clay. In fact it has the same subsoil, but with a sandy surface soil. In chemical composition the sandy surface soil of this type is somewhat lower in total phosphorus than Superior clay; the average number of pounds of phosphorus for the surface 8 inches of an acre being approximately 600 pounds; of potassium approximately 25,000 pounds; and of nitrogen 1300 pounds. The organic matter, while somewhat larger in amount than in Superior clay, should still be increased to furnish an adequate supply for the development of available phosphorus, potassium, and other mineral elements. The surface sandy soil is rather low in lime,* but the subsoil is, in most cases, well supplied with this substance, so that while light liming of the

* As this type is frequently in an acid condition, and this and other soils in the area would be benefited by the application of lime, every farmer should know how to test his soil for acidity. "A very simple and reliable method to detect soil acidity is by the use of blue litmus paper, which can be secured of any good druggist. Take a handful of moist soil and form it into a ball. Break the ball into halves and place a piece of blue litmus paper in the center on one of the halves, and cover with the other half. After 5 minutes break the ball, and if the paper is pink in spots or over the whole end, the soil is acid." "Soil acidity is also usually indicated by the growth of certain weeds, such as sheep sorrel, horse-tail rush, corn spurry, and wood horse-tail." For more information on this subject, see Bulletin No. 230 of the Wisconsin Experiment Station on Soil Acidity and Liming.

surface will undoubtedly be helpful in promoting the growth of clover, it is not likely that as large amounts of this material will be needed on these soils as will be necessary on soils where the acidity is greater.

Land values are gradually increasing, as a result of the development of the fruit industry. Ten years ago most of the land in the vicinity of Bayfield could have been bought for $5 an acre, or less. At present the areas suitable for orchards sell for $25 to $50 an acre, and even more than this if especially well located.

The following table shows the average results of mechanical analyses of the soil and subsoil of Superior sandy loam:

Mechanical analyses of Superior sandy loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	2.8	14.3	20.4	25.5	14.7	14.1	8.1
Subsoil	1.4	6.4	8.9	14.6	11.2	23.3	34.2

COLOMA GRAVELLY SAND

Description.—Coloma gravelly sand is a yellow to reddish or chocolate-colored, loose, incoherent sand, ranging from medium to coarse texture, underlain by light-red or brownish-red sand of much the same character and texture as the surface layer. Frequently the surface inch or two is of light to dark gray color, sometimes approaching black, as a result of the presence of organic matter and weathering. Both soil and subsoil carry a large percentage of rock fragments and gravel. These are of various materials among which have been recognized red, brown, and gray sandstone, granite, and other crystalline rocks, quartz, agate, and amorphous igneous rocks. Bowlders are of frequent occurrence both on the surface and in the soil and subsoil.

Scattered throughout the type are areas where the soil is somewhat heavier and better than typical. Such areas, however, could not be separated and mapped on account of their small size and the undeveloped condition of the country.

This type is of comparatively small extent and occupies only 3.9 per cent. of the area surveyed. It is confined chiefly to the west central portion of the area, northwest from Washburn from 4 to 8 miles. A small tract is found at Bayfield and another somewhat larger about six miles to the southwest, on Blueberry Ridge.

This type generally occupies the higher elevations, though occasionally it is found protruding into the valleys. As found in this area the type forms a series of rounded knolls or hills, forming a part of the Kettle Range.

The natural drainage is excessive and when brought under cultivation crops will doubtless suffer from lack of moisture during portions of the growing season.

The type is of glacial origin and is made up largely of unassorted morainic material.

The original growth was pine, which has been practically all removed, and in its place there has sprung up a somewhat sparse and unthrifty growth of birch, with an occasional poplar. The undergrowth is sumac and huckleberry, with a ground covering of wintergreen and other low growing or creeping species. In the low-lying, damp localities some hemlock, maple, and black alder are to be found growing upon it.

There are also tracts of maple and hemlock on soil of the higher areas, but such tracts are of comparatively small extent.

Present agricultural development.—Only a very small proportion of the type is under cultivation. Where typical it is less productive than any of the other soils with the exception of Beach sand. Where heavier than usual, and where the surface is not too broken, it will be a fair soil when brought under cultivation.

Method of improvement.—Coloma gravelly sand, as indicated by a single analysis which has so far been completed, has approximately 625 pounds of phosphorus, 33,000 pounds of potassium,

and 2,000 pounds of nitrogen in the surface 8 inches of an acre. It will be seen that in phosphorus it is nearly the same as that of the Superior sandy loam, and somewhat lower than that of the heavy Superior clay. It is rather low in phosphorus for soils which are to be heavily cropped, and the maintenance of a high degree of fertility will require the addition of some form of phosphorus as a fertilizer. The supply of potassium, while good in total amount, will require the presence of a larger amount of actively decomposing organic matter to render it available than these soils in their vingin conditions have on the average, so that the chief lines of improvement called for are organic matter and phosphorus. While only slightly acid at present these soils have relatively little calcium carbonate, either in the surface or subsoil, and the use of ground limestone or other form of lime will be of great benefit in the growing of clover or alfalfa—those crops which are most helpful in increasing the nitrogen and organic matter of the farm. In case of fruit lands, cover crops of some legume should be grown where an increase in the fertility is desired, though in many cases it is probable that a more mature and fruitful growth will be made without increasing the fertility of these soils to any considerable extent than would be the case if they were managed in such a way as to add largely to the organic matter, as would be desirable in raising staple agricultural crops.

CHAPTER IV.

GROUP OF MISCELLANEOUS SOILS.

GENESEE LOAM.

Genesee loam is very limited in extent and subject to considerable variation. It consists of alluvial material which has been washed down from the higher lands and deposited by the streams in times of overflow. The type consists of a brown loam or sandy loam 12 to 16 inches deep, underlain by a sand or sandy loam.

Pockets of silt and clay are found in places, and the variations are so numerous that it is impracticable to separate and indicate them on the soil map.

Only one area of this type was mapped. This lies along the Sioux River, north of Washburn. Here the type is under cultivation and produces good crops of hay, potatoes, and fodder corn. Part of it is subject to annual overflow, but the water does not cover the land long enough to prevent its being cultivated.

Small areas of this type occur along some of the other streams in the survey, but they were too small to be shown in the map.

BEACH SAND.

Comparatively little Beach sand occurs in the area. Areas are found only in sheltered bays along the main shore and chiefly along the south and west shores of the islands, which are somewhat protected from severe wave action. The north and east shore of the islands and most of the mainland consists of rocky walls.

Beach sand consists cheifly of quartz sand and some rounded gravel derived from the rocks that cover the lake bottom. Some of the material is carried down by the streams from the sandy regions and some is washed from bluffs by the

waves. Long Island consists entirely of Beach sand. The other areas are narrow strips along the shore. Where most extensively developed, the sand occurs as a low ridge from 2 to 3 feet high. At the mouth of Sand River there are two such ridges, between the Marsh and the lake front. The oldest portions of the Beach formation support a slight growth of sand cherries, a wild vetch, and some blueberries.

MARSH (INCLUDING AREAS OF SWAMP).

Marshy spots, in their present condition entirely unsuited for cultivation, are found in a number of places throughout the area. Those at the mouth of Sand, Raspberry, and Sioux Rivers, and the largest areas on Madeline Island, consist chiefly of Peat which is but slightly decomposed. These places are very wet throughout the year, and it would be difficult to drain them, as they are but little above the level of Lake Superior. The small area 2½ miles northwest of Bayfield is also Peat. The Marsh west of Ashland has a mucky peat covering for a few inches or a foot, and is underlain with clay. The higher portions of it can be useds for cutting hay, but most of it is too wet and low to be easily reclaimed.

There are a number of low-lying areas throughout the region of Superior clay where the drainage is poor and where water stands part of the year. While these places are sometimes referred to as Swampy, they should not be considered as swamp, for as soon as the land is cleared they will drain out sufficiently to be cultivated, and the soil itself does not differ materially from Superior clay. Areas of this kind are to be found on Sand, Stockton, Michigan, Cat, and Ironwood Islands, as well as on the mainland.

The areas mapped as Marsh include only those which are in a wet, soggy condition for the greater portion of the year. The inland areas can doubtless be profitably drained when the surrounding country is more extensively developed, as the streams passing through them have considerable fall. The Marsh areas at the mouth of streams, however, are all so low and so near the level of the lake that drainage would be impracticable.

CHAPTER V.

GENERAL AGRICULTURE OF THE BAYFIELD AREA.*

There are at present but few well-developed farms in that portion of the area lying to the north and northwest of Bayfield. The average size of such farms as do exist is from 10 to 30 acres. The type of farming followed on these has of necessity been general, no attempt having been made at specialization until recently.

In the last few years the tendency has been toward the raising of small fruits, together with apples and cherries. In this particular section, where sandy loam soil predominates, conditions all combine to make these endeavors successful. The adaptation of the soil can not be questioned, and the climatic conditions are highly favorable. The luxuriant growth of grasses and clover here has induced some to venture into dairy farming, mostly in a small way. No creameries or cheese factories have been established in this neighborhood, as the amount of milk produced is small and is easily disposed of as whole milk or dairy butter, in the cities of Bayfield and Washburn.

In the southern portion of the area, in the vicinity of Ashland, markedly different conditions exist, and the distribution of different types of farming with reference to soil types is admirably illustrated by the conditions existing in this area. Just as the adaptation of the sandy soils in the vicinity of Bayfield has resulted in the production of special crops, so the advancement of dairying and stock raising has gradually developed on Superior clay in the southern part of the area. In this section the greater portion of this soil type is devoted to

* See Wis. Bulletin 196—Opportunities for Profitable Farming in Northern Wisconsin.

scene of some activity in small fruit production, with every prospect of success. Some general farming is followed on Madeline Island, together with a number of small ventures in fruit growing, and an experimental orchard has been established on it by the State of Wisconsin. On the remainder of the islands much timber is still standing, although in most cases the more valuable portion has been removed.

The predominating type of soil on the Apostle Islands is Superior sandy loam, and this is more uniform in its development than on the mainland. It is the opinion of horticulturists that the islands are as well adapted to fruit growing as the mainland. Clover, peas, potatoes, oats, and wheat are being successfully raised on Madeline and Sand Islands, and general farming and dairying will no doubt be developed along with the fruit industry. The spring season is a little later on the islands, but the modifying influence of the lake makes the date of the first killing frost in the fall somewhat later than on the mainland. It is not probable that extensive development will take place upon the islands as a whole until values on the mainland reach a higher point. The only objection to the agricultural development of the islands is their inaccessibility.

FRUIT GROWING*

There are a number of factors which should be in accord to insure the greatest success in the fruit growing industry, as indicated in Bulletin No. 201, Wisconsin Experiment Station, from which data has been taken to supplement this chapter. Chief among these factors are climate, soil, elevation, and exposure, any one of which if not in the proper relation with the other factors may be the cause of failure. While apples, cherries, and a number of small fruits are successfully grown in this particular region, the fruit belt is commonly considered as occupying the entire territory suitable to apple culture.

The climatic conditions throughout northern Wisconsin are not favorable for the development of the fruit industry, ex-

* See Bulletin No. 201, Wisconsin Experiment Station on Planting the Commercial Orchard.

cept in localities which are subject to the modifying influence of large bodies of water. The portion of the Bayfield Peninsula within the present survey, and especially those portions of the peninsula immediately bordering Chequamegon Bay, are favored in this respect. The effect of the lake is to retard growth in the spring until danger of late frosts is past and to prolong the growing season in the fall. The greatest influence is immediately along the shore, and this gradually decreases as the distance from the lake becomes greater. The modifying influence of the lake, most pronounced and of greatest value for fruit growing, extends from the lake shore to the first hill top, a distance which usually ranges from 3 to 5 miles. In some places this belt is of greater width. Beyond this region there is a secondary influence from the lake extending back about 25 mies from the shore, beyond the limits of the present survey, but this is not sufficient to insure favorable conditions for fruit growing except in a few instances.

The soil conditions over most of the Peninsula and throughout a portion of the remainder of the area surveyed are well suited to the development of the fruit industry. In the vicinity of Bayfield, Superior sandy loam is the predominating type and probably better adapted to fruit growing than any of the other soils mapped. South of Washburn, and also to the west, there are extensive areas of Superior clay. Wherever there is good surface drainage, this soil is somewhat lighter in texture than typical, and it is also well adapted to fruit growing. The country to the south of Ashland is too level, and the soil too heavy, for profitable fruit growing on a commercial scale.

The elevation throughout most of the fruit belt varies from about 50 feet or over, immediately along the shore, to from 200 to 400 feet above the level of the lake several miles inland. Throughout this region there are a large number of excellent orchard sites. The orchard site should always be sufficiently elevated above the adjacent land, and the surface should have enough slope, to insure good surface drainage as well as good air drainage.

"The exposure of an orchard site refers to the general direction of the surface slope. As a rule, in Wisconsin, a northern or northeastern slope is preferable. The trees are slower

in coming into blossom in the spring than when the orchard has a southerly exposure, and therefore there is less danger from late spring frosts. Near large bodies of water best results are secured by having the exposure towards the water*."

On the Apostle Islands, practically the same conditions exist as are found throughout the fruit belt on the main land, and considerable areas on them will, when cleared, doubtless prove suitable locations for fruit culture.

Another factor of great importance in fruit growing is the selection of varieties to which both soil and climate are suitable. For best results selection should be confined to varieties which, although doing well elsewhere, seem to be best adapted to the soil and climate of the particular region under consideration. The following list is not a catalogue of all varieties of fruit adapted to the environment of this area, but it embraces most of the varieties which past experience has shown to be suited to this region and to localities similar to the Bayfield area.

APPLES.

Less than half a century ago the idea was prevalent that apples could not be made a commercial success in the Northwest. To-day, however, there are hundreds of bearing orchards throughout this territory yielding tremendous crops of magnificent fruit which brings the highest prices in the markets of the world.

The conclusion first reached was the result of trying to introduce into this region the old standard varieties of the East, so long grown on soils and under climatic conditions entirely different from those of the newer region. None of these varieties, however, found the environment provided by the new location sufficiently congenial to enable them to uphold their reputation, which had been established under such very different surroundings. It was hoped that the introduction by the United States Department of Agriculture of a large number of varieties imported from Russia would solve the prob-

* From Bulletin No. 201 of the Wisconsin Experiment Station.

lem, and that by this means the Northwest could be supplied with varieties that would prove entirely suitable. After careful test, however, it was found that while some valuable sorts were obtained from this source, as a rule the Russian varieties were to early and none proved to be entirely suitable for winter keeping. This brought to the front some of our horticulturists who had been experimenting by making crosses and raising seedling, in an endeavor to produce varieties which should combine hardiness and quality. This work has resulted in the production of some varieties in which are combined the best qualities of the old familiar varieties of the East with those of the introduced Russian sorts, and as a result of this achievement of American horticultural science, successful apple growing in the Northwest is now an accomplished fact.

The varieties most extensively grown in the Bayfield area are the Wealthy, Duchess, Okabena, and Patten's Greening. Among other varieties which appear to be adapted to this region are University, McIntosh, McMahon, and Yellow Transparent. More extensive trials will doubtless show that there are a number of other varieties suitable for the Bayfield area.

Martha, Transcendent, and Whitney are crab apples possessing many good qualities and suitable for this area. While, of course, there are many other varieties of apples and crabs that would perhaps do well in this area, those mentioned are believed to be peculiarly suited to the environment, and are varieties with established commercial reputation.

PLUMS.

While plum culture may acquire an important place in the horticulture of the Bayfield area, this fruit has been grown for so short a time that a specific statement concerning the varieties best adapted to this region would not be justifiable at present. It appears, however, from the experience acquired to date that the native varieties of plums will be the ones best suited to the conditions of soil and climate existing in the area surveyed. Some European varieties have been tried out, and while not entirely hardy, considerable success has been attained in their culture.

VIEW NEAR BAYFIELD, WISCONSIN, ON SUPERIOR SANDY LOAM, SHOWING FOUR YEAR OLD ORCHARD OF DUCHESS APPLE TREES.

Two rows of strawberries are growing between the rows of apple trees

CHERRIES.

Cherries have been grown successfully in this area for years. On many of the Apostle Islands the "Mission" cherry, as it is called, has been known for a long time and has become quite fully naturalized. It is supposed to have been introduced by the early French settlers. As the cherry will grow only on a soil that is well drained and free from constant moisture, it is especially adapted to cultivation on the rolling areas of sandy loam in the Bayfield district, and should by no means be planted on the moist, heavy clay. By reason of their superior hardiness, Early Richmond and Montmorency are the cherries recommended for this area. The English Morrell has also been quite largely planted.

APRICOTS.

As far as could be ascertained, the growing of apricots has not been attempted in this section, the impression being that this fruit is not sufficiently hardy. While this is true of many sorts, it yet remains a fact that there are many varieties of Russian origin that succeed where the other varieties can not be grown. Among the desirable sorts of this class, many of which will withstand a temperature of 30° below zero, which are recommended for trial, are Alexis, the fruit of which is large and attractive, being a rich yellow with red cheek; Superb, a golden yellow variety of large size, excellent quality, and very hardy and productive; and Budd, a late variety with large white fruit having a blush or red cheek, and perhaps the best of the late varieties for this region.

SMALL FRUITS.

Small-fruit cultivation has been uniformly successful throughout this area wherever undertaken. A careful consideration of the merits of many varieties of this class of fruits, together with a study of the soil and other conditions under which they are to be produced, leads to the selection of the following list of varieties suitable for cultivation in this area:

Of the red raspberries, the Marlboro, Cuthbert, and Miller are all desirable varieties, especially the last named. Among the black raspberries or "black caps," none are better suited for this section than Gregg, Older, and Winona. Eldorado has proved a highly desirable blackberry on the more sandy soils of this region, producing fine crops of excellent fruit. Snyder is also one of the very best blackberries for the north, being second in hardiness only to Stone's Hardy, itself a very prolific sort, of good quality, although the fruit is somewhat smaller than the Snyder. Wachusett, or as sometimes called Wachusett Thornless, is a variety of somewhat doubtful hardiness for this section, nevertheless it is worthy of trial upon the clay soils to which it is equally adapted as to the sandy types. This fact alone is deemed sufficient to warrant its mention as a variety likely to prove valuable in portions of this area.

The English varieties of gooseberries, while possessing great merit, have been found to be very much subject to mildew in certain localities, and for this area it does not seem wise to recommend them. Varieties derived from native species, although bearing somewhat smaller fruit than many of the British sorts will be found preferable. Among the best sorts for this area are the Industry, which with good care rivals the English varieties in size, and the Downey, Pearl, and Red Jacket, which are vigorous growers, free from tendency to mildew, and perfectly hardy in this area.

Currants can be grown in this area without difficulty, and are to be seen in many gardens and dooryards. For commercial culture the Cherry, Red Dutch, Perfection, and Fay's Prolific, or Fay, are desirable red varieties, and White Imperial and White Grape are popular white varieties.

While soil suitable for strawberry culture is to be found in all portions of this area, the region immediately around Bayfield presents a combination of soil and climate resulting in more favorable general conditions than exist in large tracts in other parts of the area. The sandy loam, extensively developed in this neighborhood, is an ideal strawberry soil, and the protection accorded by the heavy mantle of snow that covers the ground during the winter months renders mulching unnecessary.

Moreover, this natural protective covering remains as long as its protection is needed and disappears when no longer required.

At present the varieties most extensively grown are Senator Dunlap and Warfield. So well are these suited to the conditions in this section that it seems almost unnecessary to mention any of the others, though doubtless some of them would, if tried, prove quite equal to these. Especially is this true of those parts of the area where the soil becomes more clayey, for in the development of varieties of this fruit many good sorts have been produced that thrive in a variety of soils. Besides the Senator Dunlap and Warfield, the Bederwood, Haverland, and Glen Mary are considered to be worthy of trial on the sandy loam soils of this area. On the denser phases of the sandy loam and on the moderately heavy clay, Bubach, Jessie, Marie and Sample will, no doubt, prove highly satisfactory. For this type of soil in more southern localities Gandy is unexcelled, and if not too late in its season would prove itself highly profitable. It is, without doubt, unsurpassed in keeping and shipping qualities.

CHAPTER VI.

CLIMATE*.

Among the factors which influence the agriculture of a state, none is more important than climate. The class of crops which can be grown is largely determined by length of the growing season, and the amount and distribution of rainfall. Any one of these factors may determine the type of agriculture which can be practiced to best advantage.

The distribution of the rainfall over Wisconsin is remarkably uniform, the average yearly precipitation having a range of from 28–34 inches, while the mean for the State as a whole is 31 inches. This is a slightly heavier rainfall than is received by Eastern England, northern France, most of Germany, Sweden, and the Dundee Valley. As compared with other portions of this country, Wisconisn, has a total rainfall equaling that of central Oklahoma and Kansas, northern Iowa, Michigan, northwestern New York, or the Puget Sound Basin of Washington. But owing to its northerly location, the lessened evaporation probably makes the precipitation as effective as that of Arkansas, Illinois, or Virginia.

The local distribution of rainfall varies, however, from year to year, some sections receiving more rainfall one year, and other sections more in other years. The variation is caused by the movement of cyclonic storms. The average rainfall for the entire State during the driest year since records have been kept was 21.4 inches and for the wettest year 37 inches.

Of equal importance in agriculture to the total rainfall, is its seasonal distribution, and in this respect Wisconsin is

* This Chapter has been taken largely from Wis. Bulletin 223 on The Climate of Wisconsin and Its Relation to Agriculture, which should be consulted for more information on climate.

unusually fortunate, since about half of the total rainfall comes in May, June, July, and August, and nearly 70% from April to September inclusive. June has the heaviest rainfall averaging 4.1 inches, while July averages 4 inches and May 3.9 inches. The precipitation during the winter, on the other hand, is slight; December, January, and February each averaging from 1 to 1.5 inches of rain and melted snow. The average rainfall for the State during winter as 3.9 inches, during spring 8.3 inches, during summer 11.4 inches and during autumn 7.4 inches. Most of the rainfall occurs just preceding and during the period of plant growth, thus being received by the crop at the most effective time. Wisconsin receives during the growing season, April to September inclusive, an average of 21 inches of precipitation, which is as much rain as is received during the same months by eastern Texas, Illinois, Ohio, or eastern New York. The small winter precipitation in Wisconsin, mostly in the form of snow, on the other hand, causes virtually no leaching of fertility from the soil, nor erosion.

Another phase of rainfall distribution, of great importance, is its variation within a period of a few weeks. Frequently periods of drought and periods of unusually heavy rainfall occur, continuing for one to four weeks, and occasionally longer. Observations taken at Madison over a period of 30 years, from 1882 to 1911, inclusive, show that there are, on the average, three ten-day periods during which each growing season when the amount of rainfall is so slight that crops on a reasonable heavy soil (Miami silt loam) actually suffer from the lack of moisture. It is probable that observations in any other portion of the State would show similar conditions.

The Bayfield Area lies within the "Superior Shore" division, which is one of eight climatic provinces in Wisconsin. This includes a narrow belt adjoining Lake Superior, of unknown width, though it is unlikely that the lake influence extends further inland than twenty-five miles, and as a factor of horticultural value, it is confined chiefly to the region between the lake shore and the first hill top, which is usually from 3 to 5 miles inland. There also appear to be great variations within this belt, the southeastern slope at Bayfield being warmer, and having a

growing season much longer than the northwestern slope at Herbster. The Herbster record is so short, however, as to be of little value. This Superior shore is characterized by cool summers, with frequent northeast winds off the lake and a mean temperature (64°) like that of the coast of Maine or the Puget Sound region; pleasant, prolonged autumns, (46°) similar to those of the Berkshire Hills of Massachusetts, or eastern Washington; cold, continuous winters, having about the same mean temperature (15°) as the central portion of Wisconsin, Aroostook county Maine, the Green Mountains of Vermont, southern Minnesota, or northern Montana; and cool, retarded springs (37°), resembling the Adirondacks and the Red River Valley.

Generally, on about four winter mornings, the temperature drops to 20° below zero or lower; while on an average of five days in summer it reaches 90° or more. Sudden changes in temperature occur in this section, due to shifts in the direction of the wind. In summer, a storm coming up the Mississippi Valley causes a hot, dry wind from the south, which descending 1000 feet from the highlands is further heated by the increased pressure, and often sweeps down upon the lake shore with marked severity. The temperature may rise to over 100°, and then with the passing of the storm center to the east, a reverse breeze off the lake sets in, reducing the temperature even below 50°, and usually accompanied by rain. In winter reverse effects follow this change in wind, the land breeze being cold and the lake breeze comparatively warm.

The average length of the growing season varies from probably 150 days on the Apostle Islands, Madeline being the warmest, to an average of 130 days on the mainland near the water, diminishing probably to 115 days, ten miles inland. However, the records in this region are so few and short that estimates of the length of the growing season are merely approximate. The islands, therefore, have a growing season similar to that of the St. Lawrence Valley, northern Iowa, or eastern Colorado, but a much colder summer temperature (about 60°); while a belt ten miles inland, though it has a shorter growing season, similar to that of Central Maine, the

Catskills, Central North Dakota, or Montana, has a mean summer temperature probably 5° warmer than the islands.

The rainfall on this northern slope, owing to the lessened evaporation, and the fact that a larger proportion comes in summer and fall, is probably more effective than in the southern part of the State; but the occasional cold, wet, windy northeasters, lasting sometimes a couple of days, are very disagreeable. On the whole, this region resembles the coast of Maine in both climate and scenery, though clear and free from fogs in summer, colder and drier in winter, and covered with a deep blanket of snow from December 1 to April 1.

By reference to Figures 5 and 6 it will be observed that the average date of the last killing frost in the spring falls between June 1 and May 20th, and that the average date of the first killing frost in the fall comes between September 20 and October 10th. From the data given on these two maps the length of growing season for any portion of the State may be readily determined.

The following table has been compiled from the Weather Bureau records taken at the station at Ashland, Wisconsin. The records of precipitation cover a period of 19 years and the temperature records 16 years.

Precipitation and temperature at Ashland, Wis.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Precipitation: Mean for 19 years	1.14	1.23	1.53	2 11	3.30	3.43	4.07	3.14	3.13	2.81	1.53	1.21	28.66
Temperature: Mean for 16 years	14.8	13.6	2.37	39.6	50.5	61 4	68.0	67 1	60.4	47.8	31.7	20 4	41.6
Absolute maximum	58	55	60	83	89	98	104	97	89	94	67	55	104
Absolute minimum	–31	–33	20	6	21	25	42	37	28	13	–13	–22	–33

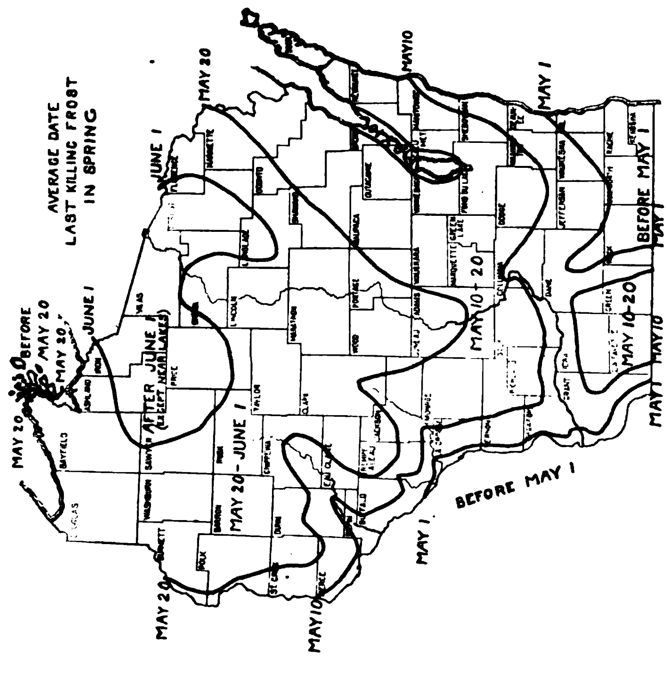

FIG. 5. LAST KILLING SPRING FROST.

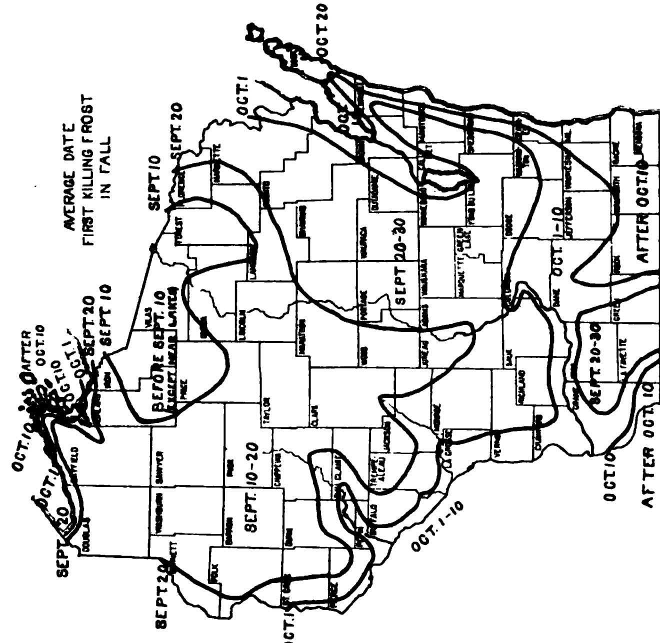

FIG. 6. FIRST KILLING FALL FROST.

These maps have been prepared from the original monthly reports of the observers of the U. S. Weather Bureau for the past 12 years, supplemented by private records.

The average date of the first killing frost in the fall at Ashland is September 21, and the average date of the last killing frost in the spring is May 14. This gives an average growing season of 130 days for Ashland and the immediate vicinity.

It will be observed from the table above that the mean annual precipitation is 28.66 inches, and that this is especially well distributed throughout the growing season, when it is most needed. The mean annual temperature at Ashland is 41.6°, the maximum 104° and the minimum—33°. The extremes of temperature are infrequent and of short duration.

Conditions on the Bayfield Peninsula differ somewhat from those at Ashland, though the Weather Bureau has no official station in the area except the one above mentioned. From the most reliable data obtainable, however, it is found that the average date of the last killing frost in the spring on the Bayfield Peninsula is May 10, and the average date of the first killing frost in the fall is October 1. This gives a period of about 140 to 145 days free from killing frosts.

SUMMARY.

The Bayfield area covers parts of Bayfield and Ashland Counties, Wisconsin, including the Apostle Islands. The survey comprises the most northerly land in Wisconsin. The northern part of the area is of a rolling, almost rugged, character, rising sharply from the lake shore with but few level areas, none of which are large.

The shore lines of both mainland and islands are bold and precipitous; very little beach formation has taken place. In the southern part of the area the land assumes a more level character, especially south of the city of Ashland. Owing to the rolling character of the land in the northern part of the area, the surface drainage is generally good; in the near-by level stretches in the southern part drainage is less efficient. Many wet spots occur throughout the whole area, owing either to the impervious nature of the subsoil, or to the topography of the surrounding country. The problem of drainage is, therefore, an important one.

The entire area was formerly covered with forests, but has been extensively cut over. It is now covered with a dense growth of birch, poplar, and other deciduous species, which, together with the pine stumps, makes clearing expensive.

Convenient transportation facilities by rail and water connect the various points within the area and afford access to the markets of Chicago, St. Paul, Minneapolis, and other large cities. Ashland is the largest city and principal local market in the area. Good local markets are also to be found in Washburn and Bayfield.

The soils of this area are all of glacial or lacustrine origin, being either deposits from the waters during interglacial periods or formed of the morainic material that marks the course of ice advance.

Superior clay, a red, dense, impervious clay of lascustrine origin, is an extensive type, especially adapted to grass and grain crops, dairying, and stock raising. When rendered less dense by cultivation and the introduction of organic matter, preferably in the form of coarse manure, it yields good crops of wheat, peas, turnips, rutabagas, potatoes, and other root crops. Lighter phases may be used for fruits.

Superior sandy loam is extensively developed in the vicinity of Bayfield, and is especially well adapted to small fruits, potatoes, and to such varieties of apples, cherries, etc., as are suited to the local climate. The sandy material formin the surface layer is glacial material; the stiff red clay may be lacustrine or lacustrine modified by glacial reworking. Though strewn with small rocks and bowlders, it is generally a well-drained, easily tilled, warm, productive soil.

Superior silt loam is similar in many respects to the Superior clay and its crop adaptation is much the same, where sufficiently level to be cultivated. It is of lacustrine origin.

Coloma gravelly sand is the least important of the extensive types found in the area. It is a poor agricultural soil, being loose, incoherent, and highly susceptible to drought. Coloma gravelly sand as found in this area is an accumlation of true morainic material, and forms a series of rounded knolls or hills, locally known as the Kettle Range. The steep slopes should be reforested.

Genesee loam consists of alluvial material, is first bottom land, and is subject to annual overflow. Only a small area is mapped.

Beach sand occurs in narrow strips along the shore, in sheltered coves on the mainland, and around the Apostle Islands. It is of limited extent and of no agricultural value.

Marsh (containing areas of Swamp) is found at the mouth of some of the streams, on a few of the islands, and in depressed areas throughout various parts of the survey.

Agricultural development has just begun. At present general farming is the prevailing type of agriculture throughout the area, but local conditions are inducing specialization along certain lines. In the vicinity of Bayfield conditions especially

favorable for fruit production exist, and the acreage devoted to the production of apples, cherries, and small fruits is steadily increasing. South of Ashland, which affords a ready market for dairy products, the soil is especially well adapted to the production of grass and other forage crops, and in this section much attention is being paid to dairying and live stock.

The winters are long and severe and the snowfall heavy. The presence of snow throughout the cold period usually prevents the ground freezing to any great depth. This is especially true in the neighborhood of Bayfield, where strawberries and other small fruits are grown without mulching. Ashland, though situated somewhat south of Bayfield, does not receive the full benefits of the influence of Lake Superior, and is uniformly somewhat colder during the winter months than the latter place. Late frosts in spring are quite unknown throughout the area, and the growing period is rapid and uninterrupted throughout the season.

KEEP THE MAP.

The Experiment Station will publish bulletins from time to time dealing with the management of the different types mapped, so that some way should be found by each person receiving a copy of this report to keep the map permanently. If the map is folded in such a way as to have the part you are interested in of a convenient size, and then have a simple frame with glass made to hold it, it can be kept indefinitely. Since some of the colors fade after being exposed to strong light for a long time, it would be a good plan to have a protecting flap of dark cloth over the map when not in use.

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

E. A. BIRGE, Director. W. O. HOTCHKISS, State Geologist
A. R. WHITSON, In Charge, Division of Soils.

SOIL SURVEY IN COOPERATION WITH THE COLLEGE OF AGRICULTURE,
H. L. RUSSELL, DEAN.

BULLETIN NO. XXXIV SOIL SERIES NO. 6

RECONNOISSANCE

SOIL SURVEY

OF

NORTH PART OF
NORTH WESTERN WISCONSIN

BY

F. L. MUSBACH

ASSISTED BY

CARL THOMPSON, THEODORE DUNNEWALD

AND

O. J. BERGH

MADISON, WISCONSIN
PUBLISHED BY THE STATE
1914

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NOTE

The Soil Survey of Wisconsin is being made along two lines, first: a general survey of the northern and less well developed portions of the state, and second: a detailed survey of the southern and older portions.

The northern part of the state has been divided into five areas of each of which a map showing the general classes of soils is being prepared.

The first area included Portage, Wood, Clark, Taylor, Marathon, Lincoln, and portions of Price and Langlade Counties. The general survey of the soils of this area was made a number of years ago and maps and reports published. The classification followed in this early work differed somewhat from that at present in use and the maps do not show as much detail as the other maps of the northern part of the state.

The second area map, called the South Part of North Western Wisconsin, includes Polk, Barron, Rusk, Chippewa, Eau Claire, Dunn, Pepin, Pierce, and St. Croix Counties. Reports on this area are now available.

This report is on the third area, called the North Part of North Western Wisconsin, including Burnett, Washburn, Sawyer, Douglas, Bayfield, and most of Ashland Counties.

A special report has been prepared on the northeastern portion of Bayfield County along the bay and including the islands, in which considerable development of the fruit industry is taking place. This is now available for distribution.

The fourth area includes Forest, Florence, Marinette, Oconto, Langlade, and Shawano Counties. The field work on this area has been completed but much work remains to be done on the analysis of the soils and the preparation of the report, so that the map and report can probably not be ready for distribution before July 1st, 1915.

The fifth area including Oneida, Vilas, Iron, Price, and the eastern portion of Ashland Counties is being surveyed this year

(1914) and a report will probably be ready for distribution about January 1, 1916.

In the detailed survey in the southern part of the state the field work has been completed in Waushara, Waukesha, Iowa, Fond du Lac, Juneau, La Crosse, Jefferson, Kewaunee, Buffalo, Columbia, and Dane Counties. The reports on Waushara, Waukesha, and Iowa Counties are now available for distribution. Those on Fond du Lac, Juneau, and La Crosse and Kewaunee will be ready about December 1, 1915, and those on the remaining counties mentioned will be printed as rapidly after that time as the analytical work and the preparation of reports can be completed.

Reports on all of these areas when ready may be secured of the undersigned.

A. R. WHITSON,
In Charge of the Soil Survey.

PREFACE.

An intelligent study of the soil is fundamental to all successful agricultural practice, for the soil is the basis upon which agriculture rests. The problems arising in the management of soils are among the most complex in the entire realm of agricultural science. In the solution of these the studious farmer can be of much assistance. Farmers, who have operated their farms for a decade or more, oftentimes without giving a thought to the principles of soil fertility, are awakening to the fact that soils are not inexhaustible, and that there exists a close relationship between yields and proper care and management of the soil. Too often, however, has the operator of a farm neglected to give heed to this relationship, and the result has been soil depletion and farm abandonment. There are few farms in the area under consideration that have been cropped for a long period; in fact, much of this section may be spoken of as virgin land. This is a distinct advantage to farmers now in the area, and others who contemplate locating here. The facts now known, relating to soils and soil fertility, as well as other phases of general agriculture, should be studied and applications made wherever possible in order to avoid some of the mistakes made by others, and to profit by the new and improved methods in farming.

Soils are found to differ in physical as well as in chemical composition, and the operator's success will be in direct proportion to the extent to which he realizes and learns these differences, and plans his methods of tillage, fertilizing, and cropping in accordance. To assist in the further study of the soils, as well as crops, and their adaptability to the soil, the state maintains two branch experiment stations, and one demonstration farm in the area, the work of which is directed by the College of Agriculture. The station at Spooner is located on sandy and sandy loam soil, and has for its main object the study of

this class of soils. At Ashland Junction the problems of the management of heavy clay soils are studied, while the farm at Superior, also on the clay soil, is purely of a demonstrational character. These institutions vary from 20 to 160 acres in extent, and are doing much to promote general agricultural development.

The survey of the soils of the state is under the supervision of the Wisconsin Geological and Natural History Survey, in co-operation with and under the direction of the College of Agriculture. One of the purposes of a soil survey is to acquaint farmers and others interested in agriculture with the different soil types in a given area. It is hoped that by means of the examinations made, both physically and chemically, together with the recommendations of the Experiment Station, that this work will become of real service to the farm operator. In this connection it should be stated that the Experiment Station will publish bulletins from time to time dealing with the management of the different types mapped, so that each person receiving a copy of this report, should make provision for preserving the map. It can be mounted on cloth for protection, and kept in this way for reference. Strong light will fade some of the colors, unless some means of preserving it is taken. The authors are fully aware of the incompleteness of this survey, but it is hoped that it will serve as a general guide to the soils of Northwestern Wisconsin, and form the basis of a detailed survey which will follow later.

T. Dunnewald assisted in the prosecution of the work in 1912, and C. Thompson in 1911 and 1912. Together they are responsible chiefly for the work in eastern Sawyer County, southern Ashland, and southwestern Douglas. Mr. Thompson also worked in the southeastern part of Burnett County, while Mr. Dunnewald did additional work in southeastern Washburn County. Mr. Bergh assisted during part of the season in 1910 in Bayfield County.

Acknowledgments. Acknowledgements are due the United States Bureau of Soils for use of part of the soil map of the Bayfield area, and also the Superior area. The mechanical analyses of most of the samples given in this report was done by the United States Bureau of Soils through the kindness of W. J. Geib, State Inspector for the Bureau.

Much assistance has been rendered the authors by lumber companies and others who furnished the party information, and assisted in furnishing means of transportation, etc. Thanks for such services are due the following:—Hines Lumber Co., at Hayward; Rust-Owen Lumber Co., at Drummond; Stearns Lumber Co., at Ashland; Theodore Okerstrom, Port Wing; Donaher Holton Co., St. Paul; Crex Carpet Co., St. Paul; Cordy Bros., Mellen; Wise Land Co., Stone Lake; Flieth-Thompson Co., Cornucopia D. M. Maxcy, Washburn; George Harmon, Spooner; W. Landraint, Supervisor of Assessments, Ashland; Good Land Co., Ashland; P. Savage, Iron River; J. W. Dady, Superintendent of Red Cliff Indian Reservation, Bayfield; and others who assisted our party in many ways. Acknowledgements are also due to F. T. Thwaites, Curator of the Geological Museum, who contributed valuable assistance in the preparation of the base map, as well as in correcting the proof maps; and to Dr. S. Weidman for suggestions and assistance with reference to the geology of the area.

The photographic views of Plate VI and figure 1 Plate IX, are from H. W. Geller, formerly Agricultural Agent for the Duluth and South Shore Railroad, and the views of Plate VIII, and Figure 2, Plate IX from H. H. Peavey of Washburn, Wis. The other views were taken for the authors by E. Ayres of Superior.

F. L. MUSBACH.

June 12, 1914.

RECONNOISSANCE SOIL SURVEY OF THE NORTH PART OF NORTH WESTERN WISCONSIN.

CHAPTER I.

GENERAL DESCRIPTION OF THE AREA.

The area discussed in this report comprises about 6600 square miles, located in the north western part of the state, as indicated on the map of Wisconsin, figure 1. It is bordered on the west by Minnesota, and on the north by Lake Superior, and includes that portion of Wisconsin lying in the extreme north western part of the state. It lies approximately between the parallels 45° 45′ and 47° North latitude, and the meridians 90° 30′ and 93° West longitude, which corresponds to the latitude of north Maine and south Washington, and to the longitude of eastern Louisiana. The tract includes Sawyer, Washburn, Burnett, Douglas, Bayfield, and nearly all of Ashland county, embracing an area larger than the state of Connecticut and Rhode Island combined, or about half the size of the Netherlands.

Early Exploration. The counties bordering Lake Superior were among the first visited by white men; and long before settlements were made, French explorers and missionaries set foot on northern Wisconsin soil. Radisson, and Grosseilliers were the first to visit this region. From 1660 to 1662, they skirted the south shore of Lake Superior and built a stockade near the present site of Ashland. They spent the winter of 1661 exploring the interior of the country south to the head waters of the Chippewa River and west to the Mille lacs region in Minnesota. Claude Allouez followed in 1665 and opened a Jesuit Mission and trading post, named La Pointe, between the present cities of Ashland and Washburn. Marquette, famous

explorer and missionary, was the last Jesuit in charge of this mission, in 1671.

La Pointe was continued, however, at irregular intervals as a trading post, first on the mainland and later on Madeline Island, up to the time of the French and Indian War, when it

FIGURE 1. MAP SHOWING THE FIVE AREAS INTO WHICH THE NORTHERN PART OF THE STATE HAS BEEN DIVIDED FOR SOIL SURVEY PURPOSES.

was deserted for a short period, but was re-established in 1765. The post became an active bartering place for nearly a hundred years. The La Pointe mission house established by Catholics in 1840 on Madeline Island is still standing a short distance from the little village which bears that name. The name La

Pointe was later applied to a large portion of northwestern Wisconsin, out of which was carved Douglas county in 1854, Ashland in 1860, and Bayfield in 1866. The area, including counties to the south, was principally a part of Chippewa and Polk counties. Burnett County, including Washburn, was set off from Polk in 1865, and Washburn from Burnett in 1883. Sawyer remained part of Chippewa County until 1883.

Early Settlements. While exploring parties had traversed large portions of the area either on foot or by canoe, permanent settlements were not attempted until the early fifties of the last century. Stimulated by love of adventure, some of the pioneer builders followed the route of Daniel du Lhut, by way of the St. Croix and Brule Rivers to Lake Superior, and began the settlement of Superior, in Douglas County, in 1854. Aside from trading and hunting, little was attempted in agriculture for nearly 30 years, when the present Omaha railroad reached the head of the Great Lakes. The first setlement in Ashland County was made by eastern people—Asa Whittelsey and others—at Ashland, in the same year that Superior was started; while Bayfield was started in 1850, also by eastern people. The Omaha Railroad reached this point in 1883, and the Wisconsin Central came to Ashland in 1877. Burnett County was peopled by Norsemen from southern counties in the State. Grantsburg was founded by Knute Anderson in 1865, but had no railroad facilities until 20 years later. Washburn County was first settled by easterners in Bashaw Valley, in 1872. Shell Lake was founded in 1880, the year after the Ashland Division of the Omaha Railroad was built. Spooner was located at the present site in 1883. Early settlements in Sawyer County followed in the wake of the railroads in the early 80's, when Hayward and other towns were organized.

Geology. The district under consideration is underlain by rock formations which consist of very old crystalline rock, and sandstone of a more recent geological period.

Crystalline Rocks. The crystalline rocks are of Precambrian Age and include granite, quartzite, and trap rock. Granitic rock occurs in the southwestern portion of area as shown in the accompanying generalized map. See Plate II. These rocks are a part of the old Isle of Wisconsin, and represent the oldest known formation in existence. The rock is, as a rule, thickly

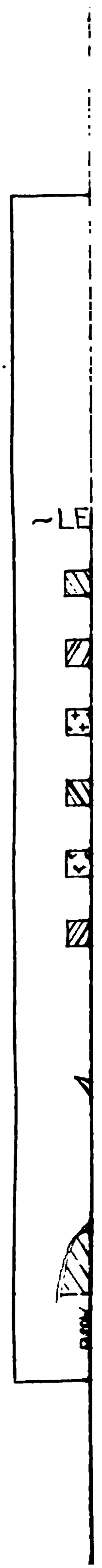
covered with glacial drift, so that exposures are found only in local areas, and usually of small extent. In the southeastern part of Sawyer County, a quartzite ridge, which is a continuation of the Rusk County Range, is a prominent topographic feature of that locality.

The Penokee Iron Ridge, which occupies a narrow belt overlying the granite, comprises not only iron bearing rock, but also quartzite, slate, and dolomite, which are quite complex in structure. From an agricultural standpoint, this latter product, consisting of a high grade of magnesium-lime rock, is of considerable economic importance. Especially is this true when it is understood that sources of limestone are unknown in this district, aside from this formation. In several locations in section 15, Township 44, Range 5 West, where exposures occur, a fine quality of material was observed occupying a nearly vertical fold 50 to 75 feet thick.

The Trap-rock (of Keweenawan Age) is an extensive underlying formation, which outcrops frequently in the form of escarpments above lower lying land. It is also known as the Copper Range, and such local names as Minong, Douglas and St. Croix Copper Range are used to designate local areas where outcrops occur prominently. In the vicinity of Mellen extensive ridges of solid rock are of frequent occurrence. Topographically, however, their influence is of relatively small importance, since the formation is covered, generally with a thick blanket of drift.

Sandstone. In western Burnett County, and southwestern Washburn County, the prevailing rock is sandstone, of later Cambrian period, which is known as Potsdam. No exposures of this rock have been found, as it is everywhere covered with a deep mantle of drift and alluvial material. This sandstone lies horizontally over the trap-rock and varies in thickness from 700 to 1000 feet. The material of the sandstone was deposited in shallow water of the sea, and the stone is, as a rule, quite soft and friable. This formation occupies also extensive areas in the central portion of the state.

The northern border of the area under consideration, including the entire Bayfield Peninsula, and continuing in a southwesterly direction into Douglas and Burnett Counties, is underlain by Keweenawan Sandstone. A portion of this formation, occupying a belt along the Superior shore, was formerly corre-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lated with the Potsdam Sandstone found elsewhere in the State, but later studies* have shown that this belt may be grouped with the main body of Keweenawan Sandstone. The beds vary from nearly horizontal layers, along the shore, to more nearly vertical ones in areas some distance back from the shore line. In color the rock is predominantly reddish to chocolate brown, with local areas of a more whitish cast. This material has been used extensively for building purposes.

Glacial Drift. Deposits of glacial material form an almost complete covering of varying depth over the entire section, so that the underlying rocks are exposed in only a relatively small area. In the Bayfield Peninsula the glacial drift is very deep, exceeding 500 feet, possibly, in most cases. The material of the drift consists of sand, clay, and gravel, and is, predominantly reddish in color.

The history of ice sheets in this area presents some complex problems, a subject, which is now under investigation by geologists. It is quite generally believed that some of the material was carried in from long distances from Canadian regions, and that the area was under ice several different times before the final retreat of the last ice invasion.

In the area under consideration, the soil has been influenced to a large extent by the underlying rock, the decomposition of which furnished material that has been reworked and modified by the action of glaciers and other agencies. For example, the extensive area of Keweenawan Sandstone underlies more than 75 per cent of the sand soils described as Plainfield Sand. The granitic and trap rock, by their decomposition and disintegration, give rise to heavier textured loam and silt loam soils. The heavy red clay soils bordering Lake Superior bear no relation to the underlying rock (Keweenawan Sandstone), since this soil type represents material deposited by water at a stage in the glacial history, when the present Lake stood at a very much higher level than at present.

Repeated glaciation has been an important agent in modifying either directly or indirectly the soils which would otherwise have been formed. In some cases only a thin coating or veneer of glacial material has been deposited, while in areas, particu-

*F. T. Thwaites—Lake Superior Sandstone.

larly in the path of the moraine, the drift material may be several hundred feet in thickness, as in the case of so-called kettle moraine which occupies the Bayfield Peninsula. Again the material carried by the ice may be entirely foreign to the vicinity in which it now occurs, as in the case of the Miami loam soil in southwestern Burnett County. The underlying rock in this area is of Potsdam Sandstone formation, yet the surface soil is limey in character.

Surface Features and Drainage. The main topographic features of the area are: (1) the sloping plains bordering Lake Superior; (2) the morainic ridge occupied by the Bayfield Peninsula, and extending southwest nearly through the entire County; (3) the nearly level Jack Pine Plains in the southwestern part of the area, lying parallel to the St. Croix River, which also forms the northern boundary of the plain; and (4) the Range Country, which produces such prominent topographic features in Ashland County, and of lesser importance where it occurs elsewhere in the western part of area.

Clay Plains. The clay plains bordering the Lake are 10 to 15 miles in width, and follow the shore line continuously, except where interrupted by the morainic ridge in the Bayfield Peninsula. The slope lakeward varies from 10 to 50 feet per mile, being less near the Lake and more abrupt with the approach of high land to the south. The principal streams draining this area are the Bad, Flag, Iron, Brule, and Nemadji Rivers. These, together with their tributaries, are usually direct-flowing streams which have eroded deep and narrow V-shaped valleys throughout their entire course, except where the land near the Lake is comparatively low, where wide valleys occur, and streams meander in their course. This plain dissection has been carried on over considerable areas, and where it exists, makes farm operations tedious and inconvenient. There is also a tendency to further depredation, since the timber and brush are being removed, and no steps are taken toward checking the process.

Bayfield Ridge. The Bayfield Ridge of morainic material is a prominent feature of the Peninsula. The ridge is between 10 and 15 miles in width and occupies the heart of Bayfield County, and is essentially a region of hills and valleys. At the southwestern extremity it drops abruptly to the Jack Pine Plains,

and at the northeast it maintains its morainic character to the water's edge. This ridge rises rapidly from the water's edge to a height of nearly 650 feet in the vicinity of Bayfield, where also well marked beach lines may be observed, indicating the height at which the water of the Lake was held by the retreating ice sheet. The north shore of the Ridge is characterized by precipitous bluffs of red sandstone, varying from 10 to 50 feet in height, except where streams have produced wide valleys by erosion. This region is peculiar in that no streams occur within the area. Small lakes are of frequent occurrence. Many of the large streams have their headwaters near the foot of this upland. Rain waters falling on the upland sink until an impermeable strata is reached, which causes the water to seek an outlet. Springs are of frequent occurrence at the foot of this upland.

Jack Pine Plains. The Jack Pine Plains occupy a broad belt from 10 to 20 miles in width, extending diagonally across the district beginning in the southwestern part of Bayfield County and terminating in northwestern Polk County. The general slope is west and southwest. It is drained by the St. Croix and its tributaries, the principal ones of which are: Nemakagon, Yellow, Clam, and Wood rivers. In the southwestern part of the Plains occupied by a broad belt of 10 to 15 miles in width in the western part of Burnett County, almost a complete absence of lakes and streams is noted. Extensive peat beds are found developed here, which apparently mark the beds of former lakes.

Range Country. The Range Country stands out in bold relief above the Clay Plains in the eastern part of area and includes the Trap and also the Penokee Range. It rises to an elevation of 900 to 1200 feet above Lake Superior, and trends from a generally northeast to southwest course through Ashland and part of Bayfield Counties. In places the underlying rock is covered with drift and is comparatively low, while in the vicinity of Mellen, some of the crests reach an altitude of 1200 feet above the Lake, or 1800 feet above sea level. Outcrops are numerous, the principal ones of which are indicated on the map. These outcrops are usually sharp, precipitous ridges which give the country a rather rugged appearance. The

Range drops abruptly southward to a gently sloping upland, forming the principal water shed of this section of the state.

The Range country in the west is included in Douglas County, and consists entirely of separated ranges of the Trap formation. These are usually of less relief than the eastern section, averaging 500 to 600 feet above Lake level. A few of the local ranges are included in the Clay Plains. South of the Range, the country is generally level, gradually sloping southward. The watershed of this section of the state is within 8 to 10 miles of the Range.

The area included in the southeastern part of the district is of a rolling character, the slope of which is generally southwest. This region is drained by the Chippewa River and its tributaries. Areas, somewhat more hilly in character, occur in a tract of varying width beginning near Lake Owen and following a southwesterly course, leaving the area near Birchwood. This tract has a typical morainic topography, and represents material of recent Wisconsin glaciation.

CHAPTER II.

GROUP OF SANDY SOILS.

PLAINFIELD SAND.

(Including Areas of Vilas Sand.)

Area. The area of the Plainfield Sand includes a broad belt of country 5 to 15 miles in width, that stretches from the southwestern townships of Burnett County in a northeasterly direction to a point about 10 or 12 miles from the extremity of the Bayfield Peninsula. A portion of the area in northern Bayfield County is separated from the main body by the undulating Vilas Sand. The slope of this belt or plain is toward the southwest in the direction of its length, with an average slope of 2 to 3 feet per mile. The St. Croix-Brule River channel, in a general way, marks the north and west boundary of the type in Douglas and Burnett Counties.

This area has been described at some length by Chamberlin in his "Geology of Wisconsin", as the "pine barrens". With respect to the origin, it is stated, that this formation is mainly the result of the sorting and stratifying action of water. At just what stage in the geological history this deposition took place, has not been definitely ascertained.

Surface Features. The topographic features are for the most part level to gently rolling, and viewed as a whole, may properly be spoken of as a plain. There are, however, areas in which the surface becomes of a rolling character, owing to glacial depressions, some of which are occupied by lakes, others by peat bogs, while some are dry. Often the otherwise level areas are marked by prominent ridges of wind blown material called "sand dunes". These are usually 25 to 50 feet in height.

In some areas it will be noticed by referring to the map, lakes are plentiful; while in others, few, if any, are found. In

the western part of Burnett County, a lakeless region occurs, and in the upper end of the Bayfield peninsula, and also in an area south of Brule River in Bayfield and Douglas Counties, a similar region is found. Through the central part of the so-called "plains," chiefly in Burnett County, lakes and streams abound. Many of the lakes are connected with one another by streams, of which the most important are the Clam River, the Yellow, and the Nemakagon.

Extensive peat marshes are frequently associated with this soil type in the western part of Burnett County. In some of the townships in this county, peat soil occupies two-thirds of the entire land area.

Soil. The soil of the Plainfield Sand is largely the result of material that has been sorted, reworked, and modified by water action, which has sifted out and carried off the finer earth particles. This process varied considerably, so that the soil resulting largely from this action, shows considerable variation. It is also very probable that in some sections, the soil has been modified by the action of ice movements over it.

In a general way, two soil types may be described, the separation of which involves the work of a detail survey. These variations are based primarily on the difference in the texture or size of grain of the soil mass, and the character and uniformity of the subsoil. By comparing the mechanical analyses of samples, this textural difference becomes apparent. No. I is taken from Barnes township in Bayfield County, and represents a loamy sand phase, while No. II, taken north of Grantsburg, is typical of the fine sand.

TABLE I.—*Mechanical Analyses of Plainfield Sand.*

No. I.

Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Surface soil, 0-8 inches.....	1.3	24.9	30.0	21.8	3.2	13.1	5.6
Subsoil, 8-24 inches....	.4	18.7	32.1	29.9	4.5	9.8	4.8
Subsoil, 24-36 inches...	.9	27.5	34.8	30.2	3.1	1.3	2.2

No. II.

Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Surface soil, 0-8 inches.....	.1	10.5	27.2	50.6	4.4	3.9	3.2
Subsoil, 8-24 inches....	.1	6.4	25.8	54.6	7.1	3.1	2.9
Subsoil, 24-36 inches...	.0	2.7	21.4	66.4	6.2	1.8	1.4

In sample No. II, will be noted the preponderance of fine sand, and the small amounts of finer earth particles—silt and clay. No. I contains less than half the amount of fine sand, but larger amounts of clay and silt. No. I also contains more coarse gravel, and coarse sand. Some times a small amount of bowldery material is associated with this phase of the Plainfield Sand.

The soil of the predominant type is the fine sand, and to a depth of 8 inches, is generally a greyish to brown fine sand, carrying a small amount of organic matter in the surface 1 to 2 inches. The subsoil to a depth of 3 to 4 feet differs very little from the surface soil in texture. The color varies from reddish brown to pink or reddish, and is quite uniform.

The soil mass is an open incoherent mass of well rounded, angular soil grains, in which quartz grains predominate. On account of this water worn characteristic, the material lacks grit and sharpness so common in some sand. Besides quartz, hornblende and mica are found, these latter two often giving the soil a greyish cast.

In certain well defined sections of small extent, the surface 6 to 10 inches is nearly black in color, and contains a large amount of organic matter which has accummulated during periods of inadequate drainage. These are usually level or depressed areas, and are found principally in Burnett County north of Grantsburg. South of Webster, also several good sized areas of black sand occur. The agricultural value of this phase is increased considerably by the added amount of humus.

The loamy sand phase occurs in scattered tracts throughout the area. Portions of township 45, Range 9, afford a good illustration of this phase. The soil to a depth of 8 to 10 inches is greyish in color, and contains more of fine earth particles than the predominant type so that it resembles a loamy sand or even a sandy loam. The subsoil usually is of a lighter color, and grades into coarser sandy material to a depth of 36 to 40 inches. Frequently small amounts of gravelly material are associated with the subsoil. This phase of the Plainfield Sand, as a rule, is superior to the other agriculturally.

In some local areas, marked variations in the subsoil were found. Along a section adjacent to the St. Croix River, in Burnett County the subsoil was found to consist of fine gravelly material, which formed an exceedingly compact mass to a depth of several feet. Again red, lake deposited clays were observed along the St. Croix River underlying the sand. At Clayfield, a fine exposure about 20 feet thick underlies the sand at a depth of about 10 to 15 feet below the surface. This bed is composed of layers, varying in color and in degrees of hardness. Water flowing over this exposure, eroded the softer material first, leaving a rather jagged cross section. This material was used in the manufacture of brick at Clayfield, and also at Grantsburg. It is used also as a base in the manufacture of paint. A pulverizer and mixer were installed along the St. Croix River recently to utilize this raw material for paint purposes. Clay out-crops frequently in other local areas, but usually at such depths as to have no bearing on agriculture, either in contributing to the soil mass, or in influencing the moisture conditions of the subsoil. Fine spring water isues from the point of contact between sand and clay along the St. Croix River, and other places where conditions are favorable for water to escape.

Native Vegetation. The predominant timber growth de-

VIEW OF PLAINFIELD SAND SOUTH OF IRON RIVER, SHOWING CHARACTER OF TIMBER DEVELOPED OVER PORTIONS OF THIS SOIL TYPE.

Jack Pine is the predominant tree growth developed on this soil. Its value has increased rapidly since the Norway and White Pine have been so generally cut.

veloped on this soil type is jack pine, and on this account the area has been referred to as the "Jack Pine Plain". There is, however, considerable difference in the size of timber and the the density of growth. In some areas only small spindly trees are found, while in others, fine tall pine, scaling 1 million to 1¼ million board feet on 160 acres. See Plate I. Usually the ground water conditions are more favorable, or the soil is better in quality where these heavy tree growths develop. While jack pine is the prevailing tree growth, areas were found in which Norway, black oak, and occasionally poplar, and birch, developed almost to the exclusion of the prevalent jack pine. In the vicinity of Bass Lake and Big Sand Lake in Burnett County there are areas several square miles in extent, in which black oak form the predominant tree species. Hazel, willow bushes,* brake, and fern are often found associated with the forest, though in many instances these form practically the entire vegetation. Severe forest fires have been unusually destructive in this region, destroying not only the timber, but also the thin covering of vegetable matter. Until recent years the demand for jack pine lumber was limited. It, however, finds a ready market now, being used largely in the manufacture of boxes and crates, as well as dimension material.

Agriculture. A large portion of the Plainfield sand is under cultivation. The crops usually grown, and the yield are:—oats, 25 to 40 bushels, rye, 12 to 20 bushels, corn, 30 to 40 bushels, and potatoes, 100 to 150 bushels per acre. Navy beans are grown as special crops in several areas, and found to be a profitable crop. The hay crop is usually limited, and consists mainly of timothy; though where the soil has been managed properly, clover may be grown. Considerable difficulty, however, has been experienced in many localities in getting good stands of clover. The usual rotation followed consists of corn and potatoes, followed by oats, rye, or buckwheat the second year, and clover the third. See plate II. Too often, however, the hay stand is limited and the rotation resolves itself into alternating grain with cultivated crops. Dairying is carried on

*NOTE—The presence of willow appears to have no relation to depth of ground water. Willows were in abundant evidence in Sections 2 and 12, township 45, Range 10, where a flow of water was difficult to obtain at depths of 70 feet to 125.

to some extent over the area, and the tendency in that direction is well established. Truck crops are also important, and together with cream and butter, form the principal cash products sold from the farm.

PLAINFIELD SANDY LOAM.

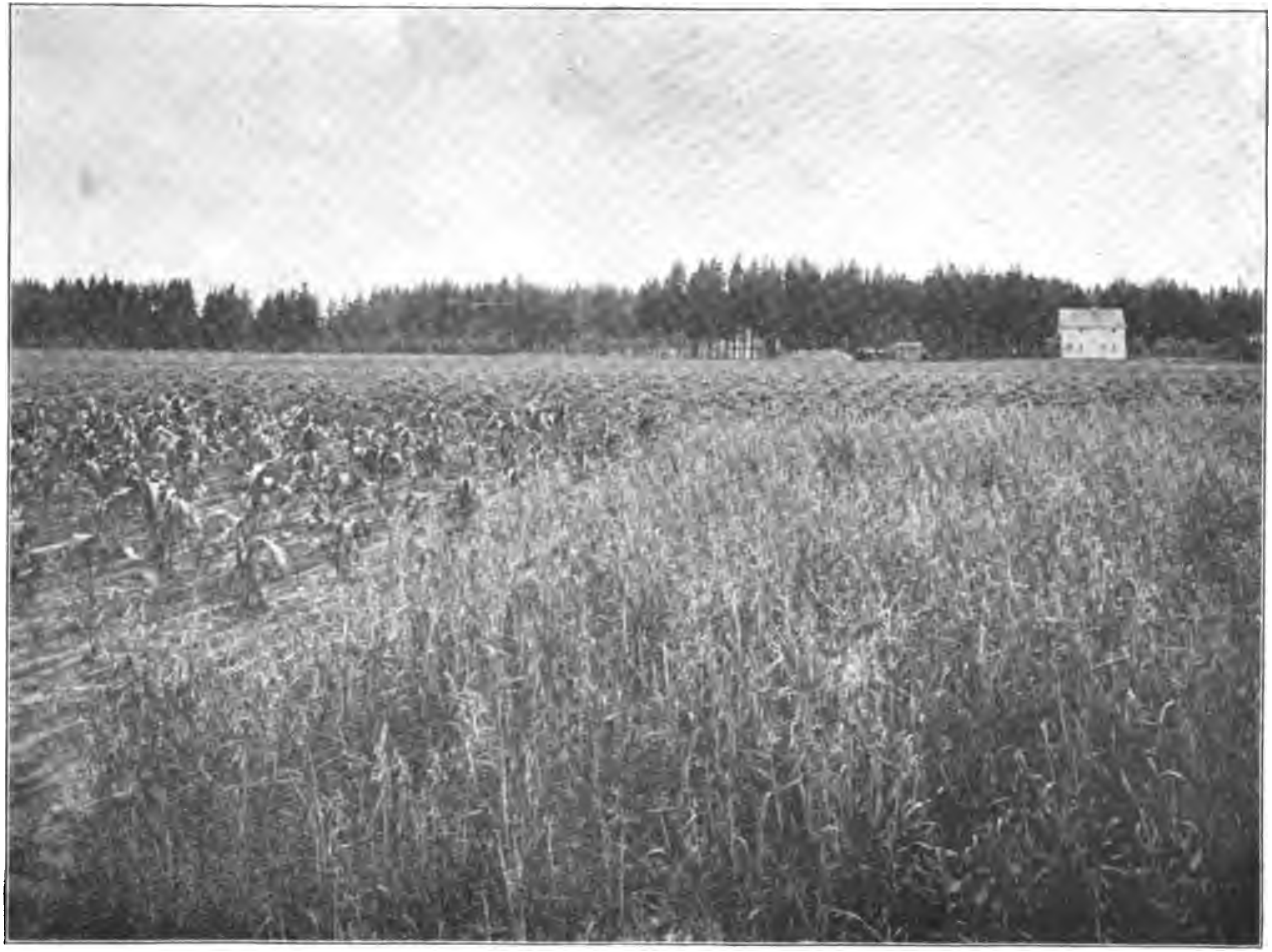
Area. The Plainfield Sandy Loam embraces an area of about 100 square miles, located mainly in Burnett County with several widely separated tracts in Washburn and Sawyer Counties.

Surface Features. The surface is generally level, becoming in places a trifle rolling. Practically the entire area is adapted for cultivation.

Soil. The soil to a depth ranging from 8 to 16 inches varies from a greyish sandy loam to loam, with which small pebbles and gravelly material are often associated. The subsoil is generally lighter in color, and carries a proportionately larger amount of gravel, and is frequently spoken of as gravelly subsoil. Strata of stony material are found at depths of 18 to 24 inches in local areas. The subsoil below 24 inches becomes more distinctly sandy, and at depths of 40 inches, sand is invariably found. In some localities, the subsoil was found to grade into fine sand at 12 to 18 inches; the gravelly material being entirely absent. Stoniness is of frequent occurrence, but seldom in sufficient quantities to interfere with agricultural operations.

Native Vegetation. The native forest growth is made up of a mixed stand consisting of black oak, birch, poplar, jack pine, and Norway pine. In certain sections of Burnett County around Doran, and in parts of Sawyer County, Norway pine with some jack pine are found; in others, jack pine is the predominant species. Practically all of the merchantable timber has been cut, the second growth forming dense thickets made up of poplar, birch, aspen, and hazel.

Agriculture. The soil is easily tilled, and well adapted to such crops as potatoes, corn, and other cultivated crops that require warm, mellow soil. Oats and rye are the principal grain crops. Barley is grown to less extent. Clovers and timothy are important crops, and grown generally. The type will maintain profitably a diversified system of farming.



VIEW OF PLAINFIELD SAND IN BAYFIELD COUNTY, SHOWING CHARACTER OF CROPS GROWN ON THIS SOIL.

This view illustrates a rotation well adapted to this type of soil. Oats stands in the foreground, cultivated crops—corn and potatoes back and at the left, and red clover in the background.

PLAINFIELD SANDY LOAM. (BOTTOMS)

Area. The area of the Plainfield Sandy Loam (bottoms) occupies level bottom lands principally along the Nemakagon, and the Yellow River, and their tributaries. It is the location along stream bottoms, or former bottom lands that have been modified somewhat by ice or water action, that formed the basis for separating this type from the Plainfield sandy loam already described. The main body occurs along the Nemakagon river, beginning at a point a few miles west from where that river heads in a lake of the same name, widening gradually until in the vicinity of Earl in Washburn county, where it is nearly six miles wide, and includes practically an entire township. West from Trego, the bottom lands of the Nemakagon disappear, the river from this point apparently having cut a new channel, the banks of which are high and uneroded. South from Trego, there are indications that originally the river flowed in this direction, but was turned from its course by the accumulation of drift thrown across its course by moving ice. The same soil formation is continued, however, farther south along the Yellow river, and in the so-called Bashaw Valley in Washburn and Burnett counties. In the vicinity of Minong, another small area occurs.

Surface Features. The Plainfield sandy loam occupies valley bottoms which are generally level. The bluffs bordering the valleys are sometimes quite steep, and vary considerably in height, ranging from 50 feet to 200. Small depressions usually occupied by peat marshes are found here and there throughout the area. Portions of the area have been modified by the action of the Ice moving over it, and leaving the surface somewhat hummocky and uneven. Sags and depressions occur here more frequently. Part of the Yellow River valley in the vicinity of Spooner is modified in this way. The Nemakagon Valley slopes at the rate of about 8 feet per mile between Cable and Trego, the fall being nearly twice as great for the upper half of the valley as the lower.

Native Vegetation. The bottom lands were timbered mainly with a dense stand of jack pine, and Norway pine; the former occupying large areas almost exclusively, and constituting much

the greater extent of the timbered land. Scattering white pine are found occasionally, especially on the heavier soil phase. Black oak, poplar, and white birch, often occur locally, instead of the usual pine, or these appear as second growth after the pine has been removed. In the Bashaw Valley, forest growth was developed only locally, large areas originally being covered only with oak thickets, instead of pine found elsewhere.

Soil. The soil is of alluvial origin, and affords considerable variation both with reference to the soil and subsoil. In a general way, three rather distinct phases may be noted—sandy loam and loam, fine sand, and loamy sand.

The *sandy loam and loam* occur mainly in the Bashaw Valley, see Plate III, in the vicinity of Minong, portions of Yellow river valley in township 39, Range 12, and the larger part of the upper Nemakagon Valley, extending southward to the vicinity of Phipps. The soil to a depth of 6 to 10 inches is invariably a sandy loam to loam greyish to brownish in color. The subsoil usually grädes into sandy material often carrying considerable amounts of gravelly material to a depth of 18 to 24 inches. Below 24 inches, the subsoil becomes quite sandy and continues to depths of 40 inches or more. Frequently clayey sand is associated with the coarse material under two feet, giving the subsoil a hardpan characteristic. This condition was found frequently in the Bashaw Valley.

A small amount of rock fragments occur throughout the soil mass, while over the surface small stones are found frequently, but not in sufficient amounts to interfere with cultivation. Slope wash from the hills adjacent to the valley bottoms often modifies the character of the soil along the bottoms near the approach of the upland, making the soil more loamy than it would otherwise be.

The *fine sandy phase* occupies a considerable tract north of the Nemakagon river between Trego and Spring Brook, and in portions of the bottom lands of the Yellow river in township 38 and 39, Range 13. The soil to a depth of 8 inches is a fine greyish to reddish sand, quite uniform in character. From 8 to 40 inches, the soil carries a trifle more coarse sand, and is lighter in color. At the lower depths the mass often contains considerable coarse material, pebbles and gravel. The line of separation between the fine sand and the loamy phase is not a sharp one,

VIEW OF PLAINFIELD SANDY LOAM SHOWING BOTTOM LANDS AND GENTLY SLOPING BLUFFS TO UPLAND. TAKEN FROM THE BASHAW VALLEY, WASHBURN COUNTY.

so that a mixture of both soils may be found in the vicinity where the one merges into the other.

In the greater portion of the Nemakagon Valley lying between Spring Brook and Phipps, and occupying approximately one-third of the entire valley, the soil is predominately *a loamy sand.* The surface 8-inches varies from a grey to brownish loamy sand to sand, carrying considerable amounts of coarse sand. From 8 to 16 inches, the subsoil becomes coarser and lighter in color, followed by coarser sand and gravelly material to a depth of 40 inches. At the latter depth, the formation is largely made up of coarse sand and gravel. The sand and gravel material comprising this soil is angular, smooth worn material, made up principally of quartz, hornblende, and mica. Small cobble stone, one half to two inches in size, are frequently found strewn over the surface.

The following table gives average results of mechanical analyses of soil and subsoil of two samples of the Plainfield sandy loam. The sample from the Nemakagon Valley represents the intermediate type, or loamy sand, while the sample taken from the Bashaw Valley is typical of the sandy loam and loam phase found in that valley, and also in the vicinity of Minong and elsewhere. No analyses were made of the fine sand the mechanical composition of which is similar to the Plainfield sand given under II on page 23.

TABLE 2.—*Mechanical Analyses of Plainfield Sandy Loam.*

Locality	Description	Fine gravel	Coarse sand	Med. sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Nemakagon Valley Twp. 41, Range 10.	Susface soil 0"–8".......	7.0	24.1	26.1	25.6	2.5	6.6	7.5
	Subsoil 8"—24"......	17.6	23.4	23.9	24.3	1.8	3.9	5.1
	Subsoil 24" 40".....	20.9	36.9	20.8	15.2	.7	1.8	3.6
Bashaw Valley.	Surface soil 0"–8".......	5.7	18.9	18.6	24.7	7.9	15.6	8.4
	Subsoil 8" 24"......	8.9	13.0	14.5	26.3	14.2	14.7	8.1
	Subsoil 24" 40".....	14.0	12.8	11.8	27.0	13.1	12.2	9.2

Agriculture. This soil type is devoted to general farming, and in part, to such specialized crops as potatoes, cucumbers, sweet corn, and beans. The Bashaw Valley is largely a dairy section, cream forming the main cash product. Potato growing is a very important industry along the entire Nemakagon Valley. The soil conditions are especially well suited for the tuber, and yields average during favorable seasons from 150 to 250 bushels per acre.

Small grains are oats, rye, and buckwheat. Corn is a crop that may be grown usually to maturity. The soil warms up early in the spring, permitting early planting. For ensilage the crop may be grown safely every year, as a rule. Clover is grown and yields well on all but the "lightest phase" of this soil. It can also be grown on this phase where proper precautions are observed, and the ground prepared properly. (See under Management of Sandy Soils.)

VILAS SAND.

Area. The Vilas Sand comprises large areas chiefly in Bayfield and Sawyer counties. Smaller widely separated tracts occur also in most of the other counties of the area under consideration. The total area of this formation embraces upward of 600 square miles, or nearly one-tenth of the entire district. In a general way, the main bodies of this soil type are co-extensive with the area of terminal moraine of recent Wisconsin glaciation. The general trend of this moraine was from a northeasterly to southwesterly direction, occupying the extensive high ridged land of the Bayfield Peninsula, and continuing in a general southwesterly course following approximately the upper course of the Nemakagon river. South of Hayward, the formation becomes more irregular in outline, and its course is almost due south, leaving the area in the vicinity of Birchwood. In the northwestern part of Washburn county, a small area occurs which extends over into Burnett county. Several other smaller tracts are found throughout the area.

Surface Features. The surface of the Vilas Sand is essentially one of hills and valleys. The slopes of the hills may be steep and precipitous, barely sufficient to hold the material in

VIEW OF VILAS SAND SHOWING CHARACTERISTIC TOPOGRAPHIC FEATURES OF THIS SOIL FORMATION. TAKEN NEAR TOPSIDE IN BAYFIELD COUNTY.

Considerable areas of Vilas sand are well adapted for grazing purposes while others should be reforested.

place; or they may be long and gentle, rising in extreme cases to heights of 100 to 200 feet above the surrounding lower land. Over considerable portions of the area, the undulations are of less relief, varying in height from low knobs to abrupt hills 25 to 50 feet in height. Sags and depressions are common characteristics, which together with the rounded hills, have lead the term "kettles and pots" to be applied to regions of this character. The sags and depressions are frequently partially filled with decaying organic matter or peat, forming marshes, or they are occupied by water, forming ponds or small lakes few of which have any visible outlet in that portion of the formation in northern Bayfield County. See Plate IV. This part of the area is also a streamless area. South in Sawyer and adjoining counties, the lakes are large bodies of water, nearly all of which are connected with some outlet tributary to the Chippewa, or St. Croix rivers. In this portion, extensive areas of poorly drained swamp lands have developed. These are for the most part heavily wooded. Gravel ridges are of frequent occurrence.

Scattered here and there throughout this extensive assemblage of hills and valleys, there occur tracts ranging in area from a few acres to 100 acres or more, in which the surface is more gently rolling or moderately level, and on which the soil is of better quality than the type described.

Native Vegetation. The main body of the area in Bayfield county was timbered largely with Norway and white pine, which has been cut long since, leaving only stumps and lone dry tree tops remaining. Forest fires have frequently swept the cut-over land, adding to the desolateness of the country. Second growths of poplar, and birch frequently follow the cut-over pine. In isolated areas through the pinery, there frequently occurred hardwood ridges in which maple, basswood, birch, and oak make up the tree growth.

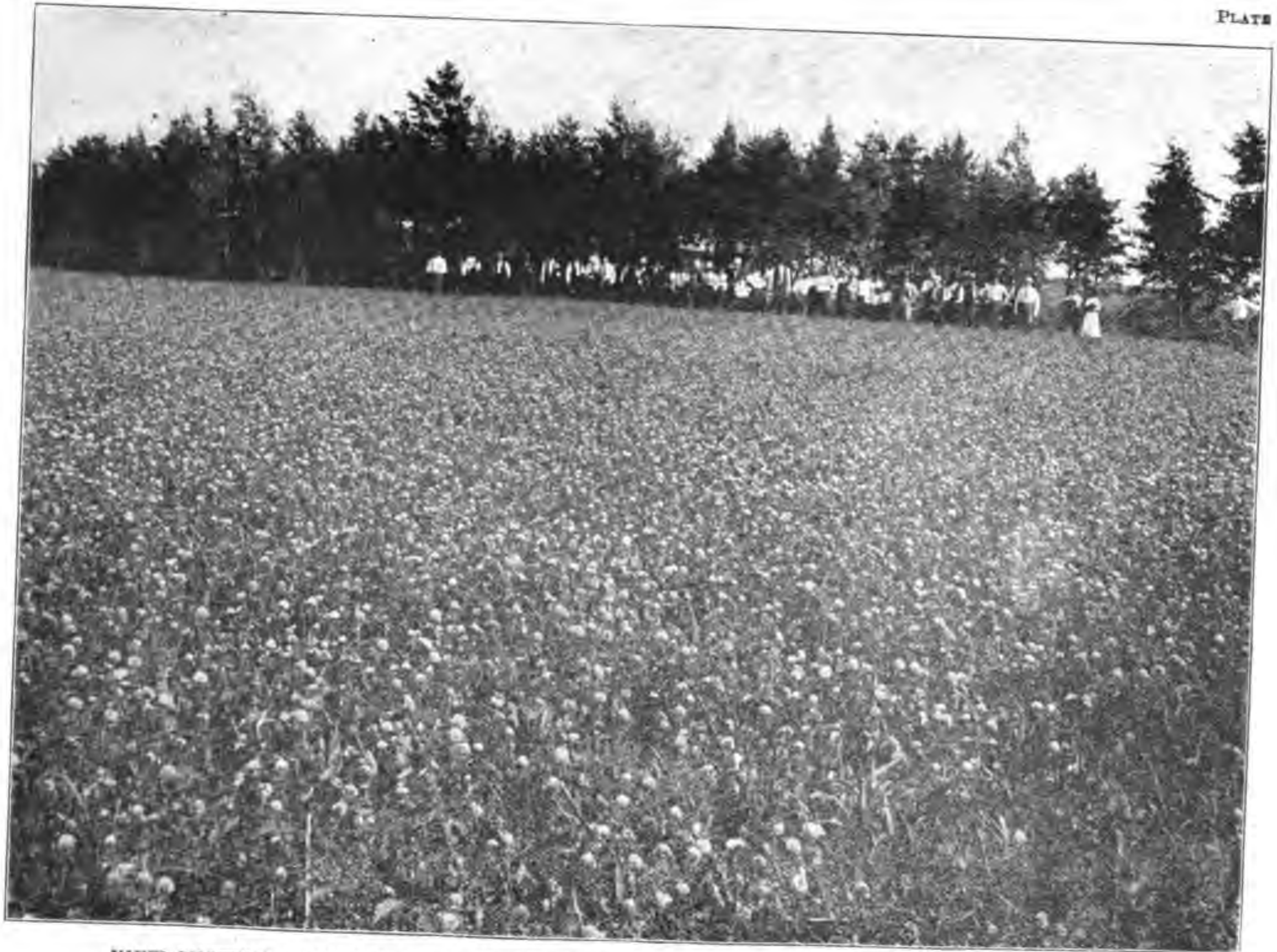
In the areas included in Sawyer, and Washburn counties, a mixed stand of timber developed; in places the pine predominated; in others hemlock, and mixed hardwood—maple, birch, and basswood, with scattering pine. The second growth is largely white birch, and poplar. Considerable areas of swamp land in northeastern Sawyer County and extending into Ashland, are wooded with spruce, ash, cedar, alder, and tamarack.

The starting point with soils which have been cropped for some time is the incorporation of organic matter, either by plowing under a green crop, preferably a legume, or by means of barnyard manure. Clover and alfalfa are splendid crops to utilize for this purpose, where these can be grown. See Plate V. The acid condition of the soil, and the lack of available plant food are, however, often causes for failure in getting a crop of either started. Annual legumes, as soy beans, cow peas, and winter vetch are acid-tolerant plants which may be grown until conditions favorable to clover and alfalfa are obtained. Rye and buckwheat are also valuable crops to turn under to increase the organic matter in the soil, but these do not add any nitrogen as the legumes do. There is, however, less difficulty in getting a fair stand of the grain crops, even though the soil has been depleted to a considerable extent. As a starter, then, they possess this important advantage over clover and other legumes.

The introduction of organic matter not only serves to increase the water holding capacity of the soil, but also through its decomposition, tends to liberate insoluble mineral plant food in the soil. This is especially true of potassium, fairly good supplies of which are contained in the soil, as shown by chemical analyses.

As the total amount of phosphorus is already low in virgin soils, the logical step is to increase the amount of this element in the soil. Where it is possible to utilize concentrated feed stuffs, high in protein, such as bran, the amount of phosphorus in the manure may be materially increased, since these feed stuffs carry considerable amounts of phosphorus. It will be found, perhaps, that the purchase of ground rock phosphate fertilizer will be the most practical method to increase the phosphorus content of the soil. This is the cheapest form in which phosphorus may be purchased, though it is not available for immediate crop use, unless it has been incorporated with organic matter—barn yard manure, or with some of the green manure crops mentioned above; the fermentation and decomposition of which serves to make the insoluble phosphate available.

Clover when once established should occupy a prominent place in the rotation. A three-year rotation, including clover one year, cultivated crop one year, and grain one year, has



VIEW SHOWING SECOND CROP OF MEDIUM RED CLOVER GROWING ON JACK PINE SANDY LOAM SOIL.

This legume should be included in every well-planned rotation. It supplies both plant food and organic matter which this soil is usually deficient in. Taken from the Spooner Branch Experiment Station.

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proven very satisfactory. A four-year rotation in which clover occupies the land two years, a portion of which is pastured, has the advantage of adding more organic matter and nitrogen to the soil. The opportunity of introducing organic matter should never be lost sight of. For example, when the corn is "laid by", some green manure crop, soy beans, vetch, and clover, should be sown, the crop allowed to make maximum growth, and then turned under.

For a complete discussion of the management and improvement of sandy soils, reference should be made to Wisconsin Bulletin No. 204, sent free upon request, by addressing the College of Agriculture, Madison, Wisconsin.

CHAPTER III.

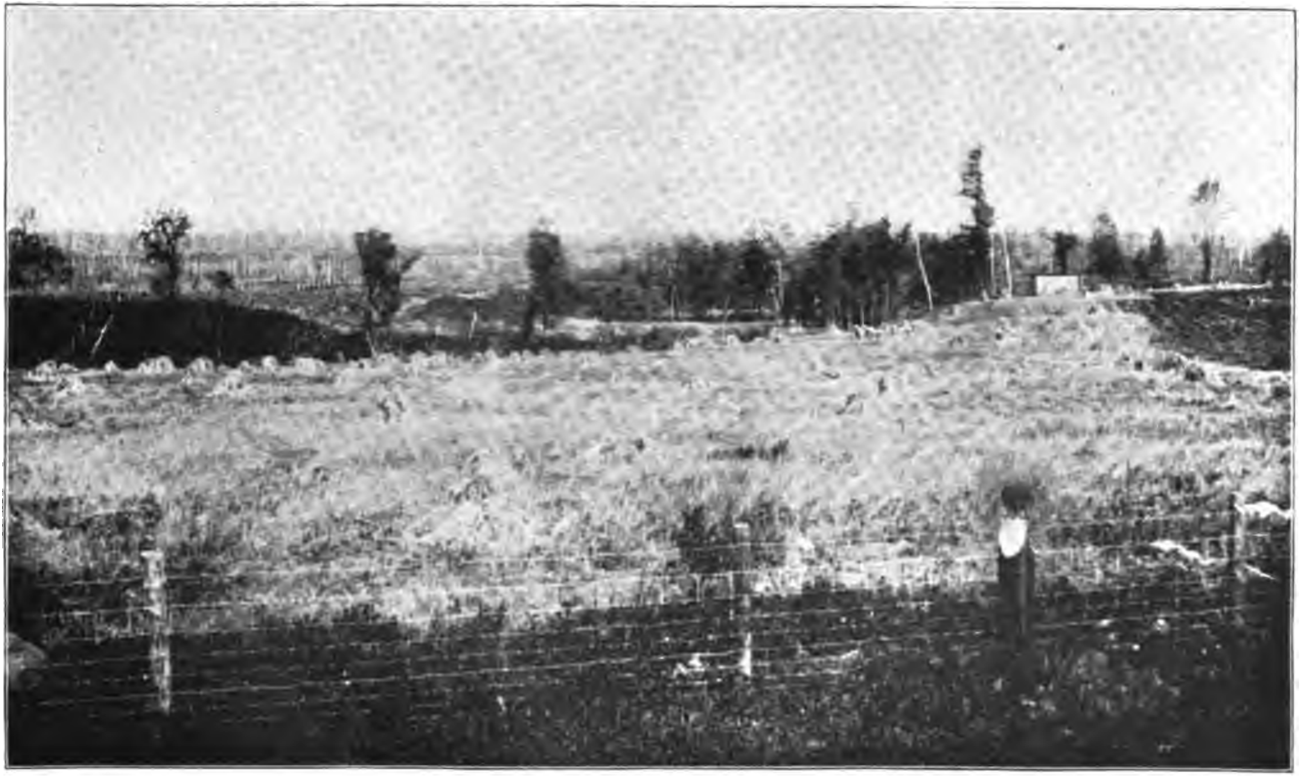
GROUP OF LOAM AND SANDY LOAM SOILS.

Mellen Loam.

Area. The area of Mellen Loam is included in a broad belt which extends in an east to westerly course nearly across the entire area under discussion. From the map it will be seen that the Plainfield Sand cutting across it in a diagonal manner separates the formation into two nearly equal areas. It occurs in every county, though only small areas are found in Burnett and Sawyer Counties. Nearly one-third of Douglas and large tracts in southern Bayfield, and in the south central part of Ashland are made up of this soil type. The entire area embraces approximately 1200 square miles or about one-fifth of the district under consideration.

Surface Features. The surface is generally of a rolling character, see Plate VI, with many depressions, lakes, and peat marshes. Frequently the surface becomes hummocky, the small hillocks varying from 10 to 30 feet in height, giving the country a somewhat billowy appearance. In the vicinity of streams the land often assumes a rather undulating and broken character. Another characteristic of the surface condition is the presence of many extensive areas of poorly drained land, most of which are covered with a deep peat soil, and densely wooded, as a rule, areas are especially prominent in the southern part of Ashland County, occurring mainly south of the water shed. Large tracts of similar areas occur in Douglas County. Streams tributary to Lake Superior drainage system flowing northward, and those flowing southward, tributary to the Mississippi River System have their headwaters in these swamps, the same swamp frequently being drained in both directions.

In regions where exposures of the Penokee Iron Range, and the Copper Range are prominent features of the country, the



VIEW OF MELLEN LOAM NEAR LAKE NEBAGAMON, DOUGLAS COUNTY, SHOWING SURFACE FEATURES AND CHARACTER OF CUT OVER LAND.

The cost of fitting this land for cultivation ranges from 20 to 50 dollars per acre. The Mellen loam is recognized as an excellent general purpose soil.

surface becomes rugged and rough. This broken area includes a belt varying in width from less than one-fourth of a mile to more than a mile.

The Copper Range rises to a height of 700 to 900 feet above Lake Superior in Ashland County, the outcrops of which become quite prominent north of Mellen, and trend in a general southwesterly course. South of Birch Lake Postoffice, a similar rugged area nearly two miles in width occurs.

South of the Copper Range, and in places closely associated with it, the Iron Range rises to an altitude of about 1000 feet above Lake Superior. On the crests of some ridges an altitude of 1200 feet is attained, making this range country with few local exceptions, the highest land in the state. The approach to this elevated region from the north is gradual and less steep than the south side, owing to a large amount of glacial material arrested by the advancing ice sheet. Rock outcrops are frequent, especially in townships 44 and 45, Ranges 2 and 3 West; township 45, Range 4, township 44 and 45, Range 5 West, and township 44, Range 6 West. Along the border of the Mellen Loam and Plainfield sand in township 44, Range 9, and township 43, Range 10, outcrops of Copper Range are also prominent. Throughout the area, outcrops of the two ranges and also of granite occur frequently. In some of the townships enumerated above, the surface features are dominated by the Range so that not more than one-third of the area is agricultural land. Stoniness is common over the entire area; in some places interfering with farm operations unless removed or collected in piles. The bowlders are mainly of local origin, and vary in size from small stone 2 inches in diameter to huge bowlders, difficult to remove.

Native Vegetation.—The area was heavily timbered with pine, hemlock, and mixed hardwoods—yellow birch, maple, bass, and oak. In certain localities, the white pine was the predominant species, while in others, hardwood, and hemlock formed the prevailing forest growth. In Douglas County, hemlock was of little importance commercially, and red oak replaced the birch. The southern portion of this county assumed the character of pinery, mainly white pine, with some Norway. In Bayfield and Ashland Counties, the Mellen Loam was timbered chiefly with a mixture of hardwoods—maple, yellow birch, and bass,—together with hemlock, and pine. In places the hard-

woods predominated, forming hardwood belts; while in others the predominance of pine characterized the area as pinery. The pine has practically all been cut, and since, hemlock, and hardwoods are being so extensively used for building purposes, the forests of Northern Wisconsin will soon become a matter of history.

Soil. The Mellen Loam to a depth of 8 to 10 inches is a brown to reddish brown loam or sandy loam, the surface 1 to 2 inches of which carries a fair amount of organic matter. Over considerable areas, the surface 2 to 3 inches is a greyish color, which changes abruptly to the typical reddish brown, characteristic of this formation. The subsoil grades into lighter colored sandy loam at about 24 to 30 inches. Below 30 inches the subsoil becomes heavier, carrying a larger proportion of fine earth particles, which gives it a greater capacity for moisture than the soil above. Over a considerable area in the vicinity of Mellen, this heavy subsoil varied in thickness from 12 to 18 inches, and is in turn followed by reddish sandy and gravelly material. In this area the so-called hard pan was found at depths of 18 to 24 inches.

The surface soil varies considerably within short distances. Frequently the hillocks are sandy and lighter in color, while the lower lying land may grade into a heavy loam or silt loam. These variations occur throughout the entire body of the Mellen Loam, and require a detail survey to indicate accurately. Stoniness is common over the soil area, but only locally in sufficient amounts to interfere seriously with agricultural operations. The soil is invariably acid even in the virgin condition. The open and porous nature of the surface soil insures good drainage, yet the more retentive subsoil prevents any undue loss by leaching.

The following table shows the mechanical composition of this soil type:

TABLE 3.—*Mechanical Analyses of Mellen Loam.*

Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per ct.
Soil	.7	10.5	14.5	27.4	14.3	26.7	6.2
Subsoil	.4	9.	15.2	32.8	17.1	19.9	5.9

Agriculture. Only a small proportion of the Mellen Loam is under cultivation at the present time. In sections where farms have been in operation for some time, the agricultural value of this land has been demonstrated. It is well adapted to diversified farming, as well as to special crops where market conditions warrant. The small grains are oats principally; rye and barley are grown to less extent. The yields for these crops are excellent. Hay consists mainly of a mixture of clover, and timothy, and yields 1.5 to 2 tons per acre. The average farm in this section contains more or less poorly drained land, which serves admirably for hay and pasturage purposes so necessary for the dairyman. Corn may be planted earlier than on the heavier soil types of this section of the state, and consequently is more liable to reach maturity before autumn frosts. For ensilage purposes, it can always be depended on. As a result, dairying is becoming the main business in this section; cream being the principal dairy product sold. This industry is growing rapidly, and with the assistance of breeder's organizations, a better quality of stock is gradually being introduced.

This soil type is also especially well adapted to trucking crops, and in local areas, this industry is growing in importance. Potatoes are always a sure crop, and one of the principal truck crops grown. Yields range from 150 to 200 bushel per acre under ordinary conditions. Bush fruits, blackberries, raspberries, currants, and gooseberries, are grown with success.

CHELSEA LOAMS.

Area. The Chelsea Loams embrace an extensive tract in the southern tiers of townships of Burnett County, a considerable area in the northern half of Washburn County, and a small area in southwestern Sawyer County. There are also many smaller tracts, often widely separated throughout nearly the entire area. Most of these tracts are isolated areas of only a few square miles in extent, which often become prominent features of the landscape on account of their elevation above surrounding country. The Chelsea soil covers a large territory in the counties farther south and east, and described in previous soil reports.

Surface Features. The surface of this soil area has been influenced profoundly by the work of glaciers. Consequently considerable variations in the surface features have developed. In a general way, the surface is characterized by areas that are rough and undulating, gently rolling, and in areas of limited extent, nearly level. See plate VII. Scattered throughout the entire area are depressions, some of which are occupied by marshes, others by small lakes. Some of the hilly land has a relief averaging 75 to 150 feet, with rather steep slopes in places; while other areas are choppy and the elevations do nct exceed 20 to 30 feet. Some of the principal hilly areas occur in the western part of township 37, range 13, and in the southeastern, and the north central part of Washburn County, and the southwestern part of Sawyer County.

Stoniness is a common characteristic, and occurs invariably to some extent over the entire area, and in places to such an extent as to interfere with cultivation. No limestone is found in the soil. Trap rock outcrops occur in the southeastern part of township 37, Range 18 in Burnett County.

Native Forests. Mixed hardwoods, and pine, are the usual tree growths associated with the Chelsea Loams. White pine, and Norway occurred exclusively in some areas, especially along the lower lying land, and scattered in through with the hardwoods in varying amounts. The hardwoods comprise maple, basswood, red oak, black oak, yellow birch, and elm. On some of the lighter soils the oak predominates forming oak ridges. The pine has all been removed, also the greater part of the hardwoods. The second growth which followed consists of poplar, white birch, and aspen making a dense thicket where left undisturbed.

Soil. The Chelsea Loams are glacial in origin, and include soils that show considerable variation in texture. In the area mapped, the predominant type is a greyish loam surface soil, followed by a greyish to reddish colored sandy loam subsoil to a depth of about 20 to 24 inches. Below 24 inches, the soil mass becomes somewhat coarser, as a rule, carrying frequently gravelly material in varying amounts. Oftentimes the subsoil at depths of 18 to 24 inches was found to consist of a reddish clayey sand, and extended down to a depth of 30 to 36 inches, where it was again followed by the usual sandy drift material.

VIEW SHOWING SURFACE FEATURES AND CHARACTER OF CUT OVER LAND OF CHELSEA LOAMS NEAR HAYWARD.

The surface of this soil area varies considerably. This view shows the more hilly phase. Where conditions are favorable the cut over lands are soon restocked with white birch, poplar and aspen.

While the predominant surface soil is loamy, there are areas, generally of small extent, which are either heavier or lighter in texture. The heavier soil is usually a grey silt loam, to a depth of 8 to 12 inches, followed by a lighter textured subsoil. The lighter soil members are sand and sandy loam. The areas of sandy soil are usually of only limited extent.

A detailed survey of this area would show a very "spotted" condition, with reference to soil types found; the changes oftentimes being very abrupt and widely different in character. This fact should be kept in mind by the prospective purchaser.

The following table gives the result of mechanical analyses of the surface soil to a depth of 8 inches and the subsoil from 8 to 24 inches, of an average loam of this type.

TABLE 4.—*Mechanical Analyses of Chelsea Loam.*

Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per ct.
Surface soil..	7.81	12.8	10.3	28.4	15.8	15.2	9.1
Subsoil	11.05	14.7	10.	27.2	16.7	12.4	7.5

Agriculture. Owing to the variety of conditions found in the Chelsea Loams both with reference to the soil types, and to the surface features, a wide diversity of agricultural pursuits is possible. Tracts, the hillsides of which are too steep for cultivation, afford good pasturage conditions, and are splendidly adapted for grazing purposes. Several "ranches" have been started recently and found profitable, as a rule. On these places, which vary in size from less than a section to several thousand acres, there is always sufficient land suitable for growing much of the grain and forage required.

The soil area taken as a whole, however, is developing into a mixed farming section, in which dairying is the most important business. Cream is the principal dairy product sold at the farmer's door to nearby creameries. The sale of live stock is an industry that is growing in importance. The dairy and stock industry is certain to develop rapidly, especially in view of the many advantages of good pasturage conditions, the abundance of good water, and the excellent yields of hay and forage crops

obtained. Clover and timothy yield well and are easily grown. Oats is the principal grain crop, and yields 40 to 50 bushel per acre. Barley, wheat, and rye are also grown to some extent. The grains and forage grown are fed, as a rule, on the farm instead of being sold in the market. The fertility of the soil, by this system of husbandry, is thus more easily maintained.

Special crops are grown to some extent. Potatoes are found to be the most profitable in this line. Yields range from 150 to 200 bushel per acre, and add considerable to the farmer's income.

MIAMI LOAM.

The Miami Loam embraces about one township in the southwestern part of Burnett County. It marks the northern extremity of a soil type extensively developed in Polk and St. Croix Counties, which is described as Cushing Loam in a report covering the latter counties.*

Surface Features. The surface features of the northern one-half of the Miami Loam are generally of a level to gently rolling character, while the area, chiefly, in Township 37, Range 18 West, is more hilly and undulating in contour, due in a measure to the presence of many lakes which occur in this section. In the more level areas, many poorly drained tracts occur, that could be benefited my tiling. Considerable tracts are now devoted principally to pasturage and hay meadows, which might be utilized for other crops, if the drainage conditions were improved. In some cases, this condition is due to obstructions, apparently the work of beavers, which serve to hinder the escape of storm waters along natural drainage channels, thus causing land to remain wet for a long time.

Soil. The soil to a depth of 8 inches is a greyish loam to silty loam followed by a lighter colored loam or sandy loam to a depth of about 20 to 24 inches, where it grades abruptly into a stiff sandy clay subsoil to 40 inches, varying from buff to greyish blue color, frequently iron stained. Upon exposure to

* Bulletin XXIII. Soils of Northwestern Wisconsin. Wisconsin Geological and Natural History Survey.

weathering influences, this material becomes reddish brown in color that is quite characteristic of the formation. In depth this "hardpan" as it is sometimes called, varies considerably. In places along road cuts the thickness was observed to be over 5 feet and is underlain by sandy drift material. A rather peculiar feature of this soil type is the presence of limestone material throughout the soil mass. Many of the pebbles which occur in the soil mass, are limestone, others are granite, quartz, and sandstone. Since the underlying rock is sandstone, the drift material now in the soil was evidently carried in by the Ice from regions where limestone abounds. The soil is invariably non-acid or only slightly acid, and not infrequently sizzles when acid is applied. The fact that this is a limey soil has considerable significance in general farm practice, especially with reference to growing legume crops.

Native Vegetation. The original timber growth consisted mainly of mixed hardwoods, and pine. At the present time, the timber most commonly found consists of white oak, black oak, maple, bass, iron wood, and ash. Of these the oak is the most abundant, and is used chiefly for fuel purposes.

Agriculture. The Miami Loam is practically all laid out in farms, and a large proportion of this soil is now under cultivation. The farmers are thrifty, specializing in dairying as their principal business. Corn is an important crop which is utilized largely for silage purposes. All ordinary small grains do well. Oats compose the principal grain crop raised, but little, if any of the grain is marketed. The main cash crops sold from the farm are dairy products and fattened live stock. Farmers are rapidly introducing pure bred and graded stock of the dairy type. Potatoes are also an important item in crops sold, especially in areas where soil is of a more loamy character. Clover and timothy are staple crops. Since the soil is, as a rule, non-acid, clovers do well. Alfalfa is being introduced, and promises to become one of the principal forage crops.

KENNAN LOAM.

Area. The Kennan Loam is limited to the southwestern part of the area under discussion, where it occupies a tract about 50 square miles, chiefly in township 42, Range 2 west in Ashland County. A small area occurs also in Sawyer County.

Surface Features. The surface of this type is that of a gently rolling to level upland, with long, sloping hills. Poorly drained areas, some of which are peat marshes occur frequently throughout the tract. Over a portion of the Kennan Loam stoniness is a common characteristic. The stony material consists largely of hardheads, granites, and quartzites of varying sizes, ranging from less than a foot in diameter to large bowlders many feet in thickness. These need to be removed or put in large piles before the land may be properly worked. Near Glidden, rocks were made to serve an economic purpose by being crushed and used for improving highways.

Native Vegetation. The area of Kennan Loam was forested originally with a dense stand of mixed hardwoods—maple, birch, basswood, oak, and elm, with scattering pine and hemlock. The pine has all been removed, and also large quantities of hardwood, though considerable tracts are still heavily forested with the latter. The cut over land soon becomes densely covered with a second growth consisting of poplar, white birch, and hardwood.

Soil. The soil to a depth of 8 inches varies from a yellowish brown silty loam to loam; the surface 2 to 3 inches often being more distinctly a greyish brown color. The subsoil grades into a yellowish brown loam, becoming a sandy loam at depths of about 20 inches, and containing some pebbles and rock fragments. Below 24 inches, the material becomes lighter in color, more sandy, and carrying a considerable amount of pebbles and stone. In the area mapped, the heavier phase or silty loam predominates, the loamy type occuring in small local areas, and lacking the uniformity of the silty loam.

Agriculture. A portion of the Kennan Loam is extensively developed, while other areas are still timbered. The cost of carving out a farm on this soil type varies, depending on so many factors that it is difficult to make even an estimate. Where

the stumpage is largely hardwood, and the land not excessively stony, the cost ranges between 25 and 50 dollars per acre. Farmers are generally engaged in a diversified system of farming. Dairying is an important source of income for the new settler. Stump land affords excellent pasturage, thus affording means of getting returns from the land, while it is being brought under cultivation.

The soil is well adapted to the growing of small grains;—oats and barley being the principal crops. A large acreage on every farm is devoted to hay, chiefly mixed clover and timothy. Corn may be grown for ensilage purposes and brought to maturity in favorable seasons. Potatoes and root crops make excellent yields, and are grown extensively.

SUPERIOR LOAM.

Area. Superior Loam embraces several small areas in Burnett County, the most important one of which is found in the vicinity of Orange. Other smaller tracts occur near Coomer, and north of Gaslyn.

Surface Features. This formation is of a generally rolling character, and, as a rule, is well drained. Sags and depressions are of frequent occurrence. Some of the poorly drained areas are covered with dense stands of swamp spruce, and black ash.

Soil. In the vicinity of Orange where it is typically developed, the surface 8 inches is a greyish loam, the surface 1 to 2 inches carrying considerable organic matter. From 8 to 16 inches it becomes lighter in color, and more of a sandy to sandy loam soil. A heavy clay subsoil is found underlying this loamy covering at depths ranging from 18 to 36 inches. In thickness, the clay varies from 1 to 3 feet, is usually reddish in color, but verges to a chocolate brown in places. In exposed cuts, this clay bed shows distinct stratification. It is underlain by stratified sandy or gravelly material to a considerable depth.

Vegetation. Originally the area supported a heavy stand of mixed hardwood and pine. The pine has long since been cut, and at the present time the forest remaining is largely hardwoods, consisting of white oak, maple, basswood, black oak, poplar, and white birch—the last named coming in as a second

growth. Often the black oak is the predominant tree over considerable areas.

Agriculture. This soil is well fitted for general diversified farming. Practically every crop that can be grown in this section of the state thrives remarkably well on this soil. Grasses and clovers make luxuriant growth and yield abundantly. Potatoes are an important cash crop. Dairy products, (chiefly butter) form an important source of income for the farmer. The tendency at present is set strongly toward dairying. Corn is a crop that matures, generally, and is used mainly for ensilage purposes.

SUPERIOR SANDY LOAM.

Area. The Superior Sandy Loam is found in each of the three counties bordering on Lake Superior. Much the greater portion, however, lies within Bayfield County, occupying mainly the so-called Peninsula. In Douglas County it occupies a belt of gently rolling land, bordering the red clay belt on the south. It occurs frequently as widely separated, isolated tracts, ranging from less than one square mile to ten or more in extent. The soils of the Apostle Islands are also largely made up of this formation.

Surface Features. The topography of Superior Sandy Loam varies from nearly level and gently rolling to rather hilly and undulating. The more undulating areas occur within the heart of the Bayfield Peninsula, where some rugged country obtains.

Rivers, which are directly tributary to Lake Superior, occupy basins that are rather wide near the mouth, and gradually taper toward the head of the stream. These streams are sometimes many miles in length, and permit uninterrupted air drainage for the valleys, the sides of which are sometimes steep and precipitous. Many of these valleys are ideally situated for orchard purposes. Post-glacial streams have eroded narrow V-shaped valleys along the slopes of these valleys, and also along the outer portion of the peninsula that has resulted in some rather broken country.

Soil. The surface soil of the Superior Sandy Loam varies from a reddish brown sandy loam to a fine sand, the surface 1 to 2 inches of which, as a rule, consists of a layer of light greyish

colored material. The subsoil underlying this formation is a heavy red clay of the same texture and origin as the type already described as Superior clay.

The depth at which this clay subsoil may appear is variable. Especially is this true in the areas that are rather undulating and hilly. Several conditions may be noted: (a) Sloping areas in which clay out crops at or near the foot of the slope, while on the higher ground near the top, the clay is not reached with a 40 inch auger, and may not be found at depths of 4 to 6 feet. Between these extremes, all gradations are liable to occur. It was also found by well records, that in some cases, the clay subsoil is entirely wanting on the higher ground. On the other hand, cases were observed where on the higher ground, providing it was level, the surface soil was found to be heavy clay followed by sandy subsoil. Such a condition was found on an upland 400 feet above lake level, east of Port Wing in Bayfield County. (b) Areas which are more nearly level or only gently rolling, and are less complicated in structure, have more uniform conditions in this respect. Over a large portion of the Superior Sandy Loam in Douglas County, and to some extent in the other counties, where similar surface conditions prevail, the heavy clay subsoil occurs at depths varying from 12 to 36 inches. In texture the soil varies from sandy loam to loam, usually reddish brown in color, and fairly uniform over considerable area. Frequently rock fragments are mixed in the body of the soil, while bowldery material is strewn over the surface. The soil possesses good drainage, as a rule, works easily, and is not subject to losses from drouth or excessive rainfall.

The results of mechanical analyses of a typical sample where the clay occurs in the subsoil at depths of less than 3 feet is shown in the following table. The sample was taken from Douglas County.

TABLE 5. *Mechanical Analyses of Superior Sandy Loam.*

Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.
Brown Sandy Loam, 0-18 inches	4.0	14.3	12.8	29.4	14.2	15.7	9.2
Red Sandy Clay, 18-36 inches	1.0	7.5	8.9	24.3	13.6	17.1	27.6

The Superior Sandy Loam is an excellent general purpose soil, and well adapted to special trucking crops. Potatoes and root crops yield well. The usual grains,—oats, barley, and rye are grown to considerable extent. Corn for ensilage purposes may be depended upon, and early maturing varieties ripen, as a rule. Usually the early Dent varieties are the best now in use. Clover and timothy are grown and yield plentifully.

Where the climatic conditions favor, however, this soil is being extensively devoted to horticultural work. It is largely on this soil type that the famous Bayfield fruit industry is developing. See plate VIII. At the present time, a large area is devoted to small fruit—strawberries, and the more important bush berries, blackberries, raspberries, and currants. The Wealthy apple, and other leading varieties, are grown, the acreage of which now totals hundreds of acres. Cherries, pears, and plums, are also grown to some extent. The Bayfield strawberries come on the market later than the southern berry, and, as a rule, command good prices. The fruit industry has passed the experimental stage, the expansion and development of which will go steadily forward.

WEBSTER LOAM.

Area. The area of the Webster loam lies entirely within Burnett County, occupying a tract nearly 100 square miles in extent. Grantsburg lies at the western extremity and Webster near the eastern. Falun and Siren, important trade centers, are also located within the area.

Surface Features. The Webster loam is characterized by a gently rolling to level surface, with considerable areas of wet land requiring drainage. On the more gentle rolling portions, drainage courses are fairly well established, which take care of excess water after spring freshets and heavy rainfall.

Soil. The characteristic feature of this soil type is the bed of heavy blue or grey clay which underlies this formation at varying depths. When it is typically developed, the surface soil varies from a sandy loam to loam, brownish in color, and extends down to a depth ranging from 8 to 24 inches, where the clay subsoil is encountered. This bed of heavy subsoil is usually

VIEW SHOWING AN IDEAL ORCHARD SITE NEAR BAYFIELD.

Until the orchard comes into bearing, the ground is occupied by bush fruit and strawberries, which yield handsome returns. The sloping land and the proximity to Lake Superior are to be noted.

less than 4 feet in thickness, on an average about 30 to 36 inches, and in turn is underlain by sandy material to considerable depths. In cuts, frequently strata of reddish clayey sand were found underlying this bed of clay, alternating with layers of fine sand. Below 4 feet the subsoil is generally found to be made up principally of sandy material. Southwest of Yellow Lake in Township 39, range 17, a small tract occurs in which the surface soil was found to be sandier than the average for this type, and the clay subsoil ranged in depth from 3 to 5 feet below the surface. This area represents the "lightest" phase of the type.

Clay Loam Phase. While the predominant soil is of this character, there are several areas included in this formation that differ to such an extent as to warrant separate description. The chief difference lies in depth of the loamy covering over the clay. In localities it may be entirely absent, the heavy clay constituting the surface soil. Over extensive tracts in the southwest quarter of Township 38, Range 18, and the northwest quarter of Township 38, Range 17, such areas occur. Where the clay becomes the surface soil, it is usually of a dark color to a depth of 1 to 2 inches, grading into a greyish or blue colored clay, which frequently is found to be iron stained. The Webster clay loam is a compact soil, and very retentive of moisture. After it has been cultivated for some time, and exposed to sunlight and air, the soil loses some of its tenacious qualities, and works more easily. These tracts are usually poorly drained.

Native Vegetation. The forest growth developed over this type is closely associated with the soil. In the clay loam areas, where the drainage conditions are less favorable, the prevailing timber is elm, soft maple, and ash. In other sections where sandy loam or loam obtains over clay, white oak, black oak, birch, maple, and bass are found. In a few areas, jack pine and white pine developed. Jack pine was found in the tract near Yellow Lake where the surface soil is more sandy and the clay lies somewhat deeper.

Agriculture. This soil is adapted to a considerable variety of uses. Dairying is found profitable on the clay loam. Excellent stands of grasses, and clover for hay are grown. Pasturage conditions are also exceptionally good. Oats is the principal grain crop; barley, rye, and wheat are grown to a small extent.

The sandy loam and loam soils are special crop soils, a large acreage of which is devoted to potatoes each year. Oats and rye are the principal grains grown. Corn is grown to maturity on the warmer, lighter soils, but less successfully on the poorly drained clay loam soils. Practically all the crops, except potatoes, and small amounts of grain and some hay are fed on the farm and sold as manufactured products—cream and fat stock. The dairy end of farming is destined to become more important. A better quality of stock is also being introduced more generally by the farmers.

Drainage. In order, however, to obtain the best results, and insure certainty of crops, it will be necessary to improve the drainage conditions on the more nearly level areas. This applies on the sandy loam as well as on the heavy clay loam soil. Surface ditches have been found helpful. Oftentimes, a farmer has difficulty in getting an outlet, unless adjoining farmers cooperate in constructing a final outlet to stream beds. Tile drainage has not been tried, many farmers doubting whether the heavy tight clay soil could be drained. On similar soils, tiles have been in operation for several years, and their efficiency can no longer be questioned. The soil, though fine and closely grained, possesses the peculiar property of checking and cracking, which assists in establishing water courses toward the tile. These become quite permanent after continued use, and serve as a means for rapid removal of water in the soil.

Depressions in the sandy loam areas which are often difficult to drain, and on which water stands frequently for a long time, may be benefitted by a vertical drain system. The heavy clay is practically impervious to moisture, but when an outlet is established through it by means of tile set on end, the water soon disappears in the deep bed of sandy material which underlies the clay.

RICE LAKE LOAM.

This soil type embraces about three square miles in Township 37, Range 11 West, Washburn County. It is a continuation of the soil type mapped "Rice Lake Loam" in Bulletin No. XXIII, Soil Survey of Part of Northwest Wisconsin.

The soil to a depth of about 6 inches is a greyish silt loam, followed by heavy silt loam subsoil of distinctly buff color, to about three feet. Beneath this heavy subsoil, the soil grades into sandy to gravelly loam. The formation occupies nearly level bottom lands or valleys, and is of alluvial origin. Further south in Barron County the soil assumes more of a loamy character. In this area, however, it is distinctly a silt loam. For the most part this was heavily timbered with mixed hardwoods, only small areas of which now remain. Agriculturally, this is a highly productive soil, and is developing into one of the finest general farming sections of the state. Diversified farming is pursued, with dairying as the principal business; cream being the leading product sold from the farm. Potatoes and peas are special crops grown quite extensively. The usual small grains are generally grown and yield well. Corn is grown mainly for ensilage purposes.

GENESEE LOAM.

This soil type is made up largely of material that has been transported from higher land and deposited upon lower ground. It is of limited extent, and shows considerable variation in texture. The surface varies from a sandy loam to loam with subsoil that depends somewhat on the adjacent soils. In the area along the Marengo River and tributaries of White River, the subsoil becomes quite clayey, while the surface is a fine sandy loam. Along the Sioux River, in Bayfield County the surface 12 to 16 inches is a brown loam underlain by sand or sandy loam, followed by clay at a depth of 3 to 4 feet. The area in the vicinity of Shell Lake is a sandy loam with a subsoil to a depth of

3 to 4 feet of sandy material. The type is of too limited an area to be of much importance agriculturally. Wherever it occurs, the soil is found to be fertile and productive. It is subject to overflow in some instances, and is then adapted for pasturage purposes to advantage. Hay, corn, potatoes, and small grains are the usual crops grown.

CHAPTER IV.

GROUP OF SILT LOAM SOILS.

Kennan Silt Loam.

Area. In the area under consideration, the Kennan Silt Loam includes nearly the south half of Sawyer County, and about one township in Ashland County. The total area mapped in this section of the state amounts to about 800 square miles. It is, however, one of the most extensively developed soil types in the north central part of the state, embracing a large part of Rusk County, parts of Chippewa, and Lincoln County, and is described in some of the previous reports as Kennan clay loam.

Surface Features. The surface of this formation is of a rolling character. A noticeable feature is the long sloping areas between drainage channels often spoken of as ridges. The Thornapple Ridge, east of Winter, Sawyer County, affords a good illustration. Occasionally, areas along streams or near marshes are found in which the surface becomes more choppy; the hills or knobs in such cases being only of moderate height and not too steep to permit cultivation. Again tracts of considerable area occur in which the surface is level and plain-like, and in which surface drainage is inadequate, and tiling will be needed in order to obtain the best results. In many of these level tracts, depressions occur in which vegetable material has accummulated and resulted in the formation of peat beds of varying extent. Areas comprising several square miles occur frequently, while smaller tracts are found commonly over nearly the entire area. As a rule they are heavily wooded with species adapted to these conditions. Cedar, spruce, tamarack, and ash, are the predominant forest trees found. Frequently one or two species predominate, but more often a mixture of all of these has developed. The Flambeau and the Chippewa rivers and their tributaries drain the tract.

Stoniness is a feature of local importance over the area. Much of this formation, however, is so inaccessible at the present time, that only a general statement may be made with reference to this feature. It may be said, however, that more or less stone are found scattered over the entire area, and in local areas in such quantity as to add considerably to the cost of clearing land.

Native Vegetation. This soil formation developed stands of timber consisting of mixed hardwoods, hemlock, and pine. The pine, (mainly white pine) was of relatively small importance. It occurred scatteringly throughout the mixed hardwoods, but often in local areas along lower ground it was the predominant species. Hemlock, yellow birch, and maple, in the order, made up the bulk of forest stand which in virgin state ranged from three to five thousand feet per acre of stocked areas.* The pine has been cut out and at the present time, hemlock, and birch is being rapidly removed. The wooded sections of parts of Sawyer suffered severely from wind storms, as indicated by numerous tracts of windfalls. Forest fires have also swept over considerable areas of the slashings and the timbered land. Within a few years after fires have run over the land, it is covered with a thick stand of volunteer poplar, birch, alder, and berry bushes.

Soil. The soil of this formation to a depth of 8 inches, is a grey to buff colored silt loam, carrying a considerable amount of very fine sand. The subsoil to a depth of about 18 to 24 inches is a yellowish to light buff colored silty to clayey loam. This is often mottled by iron stains which upon exposure gives the soil mass a characteristic greyish-yellow color. The mottling, while quite characteristic, is often lacking, especially if the surface silt loam is shallow and followed by sandy subsoil. Below 24 inches the subsoil becomes more of a clayey sand, reddish in color and carrying a small amount of medium sized pebbles. This stiff subsoil is often spoken of as hardpan, and varies from 12 to 24 inches in thickness. It is followed by a reddish colored loose sand and gravel for considerable depths. In cuts this loose material was seen to extend to a depth of 6 and 7 feet. The thickness of the surface silt loam covering varies considerably. Often times when the topography becomes roll-

*Forest Condition of Northern Wis. by Roth. U. S. Dept. of Agr.—1898.

ing to hilly, the higher points have a silty covering not to exceed 4 to 6 inches, and in some places observed the lower sandy subsoil has become exposed on the tops of knolls and formed the surface soil. Again over the more nearly level areas the silt covering may extend down 3½ to 4 feet, followed by the usual subsoil described above.

The following table gives the result of mechanical analyses of typical samples of this soil:

TABLE 6.—*Mechanical Analyses of Kennan Silt Loam.*

Locality	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Winter—							
Surface soil....	1.1	1.9	1.5	3.3	29.2	44.0	18.8
Subsoil..........	1.9	3.2	2.2	4.3	37.3	36.4	14.6
Exeland—							
Surface soil....	1.9	8.2	5.7	7.2	23.0	44.1	9.6
Subsoil..........	2.9	8.8	7.0	8.0	26.3	35.7	10.9

Agriculture. Probably less than two per cent of the Kennan Silt Loam is under cultivation. The land is either forested or cut over slashings through which forest fires have run repeatedly. The logging business is still an important industry in a large section of the area. Several fine farming communities have been developed. At Exeland, and also at Winter, in Sawyer County, good sized farms have been established, which show the agricultural possibilities of this soil type. The soil is of sufficient depth and of such a character that it retains an abundance of soil moisture needed for growing crops. Grasses and clover find in this soil conditions for exceptional growth, and no where in this section of the state are yields surpassed. Grains—oats, barley, and wheat are grown and produce plentifully. Peas, both for stock and for canning purposes, will be a profitable crop to grow. Root crops—mangels, rutabagas, and turnips are crops that make excellent yields. The dairy farmer will find these valuable as a source of succulent feed for his stock. Potatoes are grown to a considerable extent, and form an important cash crop for the farmer. Corn can always be relied upon to mature for ensilage purposes. The need is ap-

parent, however, for earlier maturing varieties. The work of acclimating a variety is dependent largely on local conditions, hence the need of selecting and planting only early maturing varieties.

Dairying will unquestionably develop as the most important business. The many streams furnish water in abundance for stock, except on the "Ridge" lands where wells are 100 feet or more in depth. Sufficient water for the home may be obtained in wells 25 to 40 feet in depth.

Land Clearing. Wild land is generally held at \$10.00 to \$25.00 per acre, depending on location. Improved farms with good buildings are valued at \$60.00 to \$80.00 per acre. One of the first questions asked by the prospective purchaser of land, after he has examined the soil conditions is, what is the cost of clearing the land and preparing it for cultivation. To answer this question at all satisfactory, one must know the condition of the land to be cleared with reference to the number, size, and character of the stumps per acre. Heavy pine stump land costs relatively much more to clear than hardwoods. The latter decay, especially if the land is pastured, while pine stumps are less subject to decay, and always require more energy in removing than do hardwoods. The length of time since the timber was cut has an important bearing on the cost of clearing. Hardwoods are affected to a greater extent in this respect than pine. The character of the soil is also an important factor in land clearing. On the heavy clay and loam soils, dynamite is more effective than on the lighter sandy types. On the other hand, the lighter soils are more easily broken than the loams. The condition of the soil is also important. As a rule, much more effective work can be done when the ground is wet than when it is dry. The amount of brush, dead timber, and second growth which is necessary to remove, varies considerably, and likewise the cost of doing this work.

The new settler seldom attempts to clear his breaking of all stumps and stones the first year. It is neither necessary nor profitable to do so. The preferable way for him to do is to clear the land of all underbrush, dead timber, and stumps that are easily removed. In most cases, in the mixed hardwood country, this may be done at a cost of about 6 to 10 dollars per acre. The land should then be seeded to clover, and harrowed with a spring

FIG. 1. A CHEAP BUT SATISFACTORY STUMP PULLER.

The best results are obtained by supplementing its use with dynamite.

FIG. 2. THE STEAM PULLER WITH ATTACHMENT FOR PILING STUMPS IN HUGE HEAPS.

This outfit does very effective and rapid work. The cost of this equipment limits its use, however, unless financed by a company which makes land clearing a business.

tooth harrow. This will afford excellent pasturage and hay for cows and stock, which prevents brush from coming up, and provides also a source of income for the farmer. A portion of the land may be utilized for small grains, potatoes, and other crops needed for maintenance. The stumps are then removed gradually year after year. Continued working and pasturing stump lands assist in decay processes, and afford better conditions for frost action, thus materially lessening the cost of final clearing.

Where the settler wishes to clear his land of all stumps and debris at once, the combined use of dynamite and some simple stump pulling outfit, has been found very satisfactory and economical. A drum and cable mechanism, or a wheel and axle mounted on a tripod are efficient machines to use. See Fig. 1, Plate IX. Home made affairs of either type are equally good. The cost of clearing land by this method on average mixed hardwood and pine land that has been cut over for a number of years, will range from $20.00 to $50.00 per acre, including the cost of dynamite.

Undoubtedly the use of more important methods, including the steam stump puller, (See Fig. 2, Plate IX) will do much to reduce the cost of clearing the vast areas of undeveloped agricultural lands in this section of the state. Thus far, the cost of large power equipment has made its use almost prohibitive, unless financed by a company who make land clearing a business. This it seems would be the most satisfactory way to handle the proposition. Steam pullers have been in use in Bayfield County and elsewhere the past few years.

MELLEN SILT LOAM.

Area. The Mellen Silt Loam embraces three widely separated tracts of nearly equal area—one in southwestern Douglas County, another at the intersection of Douglas, Bayfield, Sawyer, and Washburn Counties; and the third includes portions of the southern tiers of townships in Washburn County. The total area aggregates about 250 square miles.

Surface. The surface is generally rolling in character, some parts of the areas becoming nearly level, while others in the

vicinity of streams, are slightly rougher. Small, flat, wet areas occur frequently. These are usually poorly drained, and heavily wooded with tamarack, spruce, and cedar. Frequently areas occur which present a hummocky appearance, the elevations scarcely ever exceeding a height of 20 to 30 feet. This condition occurs in portions of southern Washburn, while the poorly drained flats are more commonly found in southwestern Douglas.

Native Vegetation. The original timber stand consisted of a dense growth of hardwoods, pine, and hemlock. The pine was cut 20 or 30 years ago, and the hemlock has been practically all removed during the last decade. At the present time, considerable maple, birch, bass, and oak remain. The second growth consists principally of aspen, birch, and hardwood saplings.

Soil. The Mellen Silt Loam to a depth of 8 inches is a grey to buff colored silty loam, underlain by a distinctly buff colored subsoil of silty material which is often mottled and streaked. The depth of this subsoil varies somewhat; ranging from 12 to 24 inches, where it is followed by a reddish fine sandy loam, or gravelly loam, which grades into reddish sand and gravel at lower depths. At depths of 10 to 15 feet, cuts showed the soil mass to consist entirely of sand. Small stone are often associated with this subsoil.

While the type runs in general quite uniform texturally, yet there are areas included which differ from the established type in that the covering of silt may be only a few inches thick or entirely wanting and the surface soil is found to be a greyish sandy loam with light textured subsoil. These areas are usually small, isolated tracts, occupying the ridges and crests of knolls. These local variations were impossible to separate, and in many cases, are too small to indicate on a map of the scale used.

The chemical analyses of this soil show a satisfactory condition with reference to the usual plant food constituents, with the exception of phosphorus, which is found rather low, averaging about 1100 pounds over an acre to a depth of 8 inches.

The results of mechanical analyses of a typical sample of the surface soil and subsoil of this type is shown in the following table:

TABLE 7.—*Mechanical Analyses of Mellen Silt Loam.*

Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	per cent.	per cent.	per cent.	per cent.	per cent	per cent.	per cent.
Surface soil........	.3	5.1	4.0	4.6	12.4	64.4	8.9
Subsoil.............	.3	6.1	6.0	7.1	11.9	58.7	9.9

Agriculture. The Mellen Silt Loam where it has been brought under cultivation is found well adapted to diversified farming. The usual small grains—oats, barley, wheat, and rye, may be grown successfully. The principal grain crop grown is oats, the average yield of which ranges from 40 to 50 bushel per acre, barley 35 to 40 bushel, wheat 15 to 20 bushel. Clover and mixed hay yield 2 to 2½ ton per acre. Alfalfa has been tried, experimentally, with success. The soil, being acid, requires liming to insure a stand. Potatoes are a special crop. Corn is grown largely for silage purposes.

Dairying is the important business on the farms of this soil type. This industry is rapidly expanding, both as to numbers as well as in the quality of the stock maintained. The principal dairy product is cream sold to local creameries.

ANTIGO SILT LOAM.

Area. The Antigo Silt Loam* occurs in limited areas in southeastern Burnett County, in the southern part of Washburn, and several areas in the northwestern part of Sawyer County. The tracts range from less than one square mile to ten or more in extent, and aggregate about 75 square miles.

Surface Features. The surface features of this formation are generally level to gently rolling. Frequently there are areas slightly rolling in character, in which sags and depressed areas occur, some of which are occupied by small lakes, others by marshes. These areas occupy, however, only a relatively small proportion of the total area.

*The Antigo silt loam has been mapped Milltown loam in Bulletin No. 23. South part of Northwestern Wisconsin.

Native Vegetation. This soil was originally densely forested with hardwoods, pine, and hemlock. The hardwoods consisted of maple, oak, yellow birch, and some basswood. At the present time all of the pine and hemlock, and most of the hardwoods have been removed. Poplar, birch, and maple form dense stands cf second growth where the cut over lands have been left unimproved.

Soil. The soil to a depth of 8 to 10 inches is a greyish silt loam, followed by a buff colored clayey silt loam to a depth of 24 to 30 inches. The depth of this clayey subsoil may vary somewhat. In several places it was found to extend down to a depth of 3 to 4 feet, though the average depth is less. This tenacious subsoil is frequently mottled, and often carries a small amount of rock fragments. Below 30 inches the subsoil grades into reddish sandy material, with which a varying amount of gravel is associated. This subsoil condition is very favorable for underground drainage, while the blanket of heavy surface soil is everywhere sufficient to retain moisture for the growing crop. Over some of the more level tracts, the need of artificial drainage is apparent; but, as a rule, the land has good natural drainage. Aside from variations in the depth of the heavy subsoil, this type is quite uniform in character. The soil is generally free of stone, works easily, is not subject to baking, and considered one of the most durable soils in the entire area. The results of mechanical analyses of a typical sample of the soil and subsoil, taken near Sarona, in Washburn County, is shown in the following table:

TABLE 8.—*Mechanical Analyses of Antigo Silt Loam.*

Description	Fine gravel	Coarse sand.	Medium sand	Fine sand	Very fine sand.	Silt	Clay
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Surface soil........	.2	3.0	3.3	3.8	12.0	68.8	8.7
Subsoil..............	.3	2.6	3.0	3.5	11.6	65.8	13.4

Agriculture. A general diversified system of farming is followed on this soil type. It is capable of maintaining excellent dairy farms, and the tendency in that direction is now well established. In some of the communities where dairying has been

established for some time, graded and pure blooded stock is rapidly replacing the unprofitable scrubs. This phase of dairying deserves greater attention by farmers who have in many cases not appreciated its importance. The principal dairy product is cream. Stock raising is also important; fat cattle and hogs being the principal products sold.

Oats is the principal grain crop raised and yields well. Wheat, barley, and rye, are also grown, but to less extent. Mixed clover and timothy hay occupies considerable acreage on every farm. Many instances were observed, however, where fields were left in hay too long, resulting in unprofitable yields. Corn is a crop largely used for ensilage purposes, but may also be grown to maturity. In common with all northern sections of the state, the work of selecting and growing early maturing strains is of vital importance in assuring a crop each year. Wisconsin No. 8 Yellow Dent, and Yellow Flint, are varieties of corn that thus far have been found very satisfactory both as to yield and maturing qualities.

The areas in Burnett and Washburn Counties, and some in Sawyer are practically all divided into farms, some of which have 50 to 75 per cent of the land now under cultivation. Improved farms are held at $75.00 to $100.00 an acre, depending on the improvements and location. The unimproved land is held at $15.00 to $25.00 per acre.

COLBY SILT LOAM.

Description. The Colby silt loam soil embraces a portion of one section in Washburn County in Township 37, Range 11, West. This small area marks the northern boundary of a soil type that occurs extensively throughout Central Wisconsin. It is described quite fully in preceding reports, covering this section of the State. The soil to a depth of 6 or 8 inches is a greyish silt loam, followed by a buff colored silty subsoil. Below 18 to 24 inches the subsoil becomes more clayey in character, and is frequently iron stained.

The surface of this formation is rolling, with broad, long, sloping valleys. Areas of comparatively level land are also common.

The forest growth consisted mainly of mixed hardwoods, and pine. The latter has all been cut, but considerable tracts of mixed hardwoods still remain. While the work of clearing this land is somewhat slow, yet fine farms are developing quite rapidly. Dairying is of first importance, and keeps pace with the increase in cleared land. The usual small grains are grown. Root crops, and such special crops as peas, sweet corn, and beans, are also grown quite extensively. Clovers and timothy are big yielding crops. Corn occupies a large acreage, and may be grown to maturity, as a rule.

CHAPTER V.

SUPERIOR CLAY.

Area. The area of the Superior clay is included in a broad belt bordering Lake Superior, and extending inland a distance varying from a few miles to nearly 20. On the south, the clay belt terminates rather abruptly in higher land. That portion of the belt skirting the Bayfield Peninsula has been modified somewhat by ice movements, so that the formation is irregular in outline. Here it occurs more often as small areas varying from a few square miles to a township or more in extent. On either side of these small areas, usually occur ridges of higher land described as Superior sandy loam. The total area of Superior clay approximates 1000 square miles.

Soil and Surface Features. The Superior clay is a heavy compact soil of a distinctly reddish color. The subsoil differs but little from the surface soil in color or in compactness. Usually a thin coating of vegetable material is found over the surface. From well records and exposures along stream cuts, the clay from the lower sections was found identical with that near the surface, both as to color and texture. After the land has been cultivated for some time, and exposed to air and sunlight, and more vegetable matter from crop residues has been incorporated into the soil, it gradually "lightens" up, is less reddish in color, and assumes more of a clay loam character. This is the condition in older sections of the state, where the same soil type has been devoted to farming for 40 to 50 years.

Here and there sags or depressions occur, in which the drainage is usually poor, and the accummulation of vegetable matter gives the soil a black color. These areas are small as a rule, and when drainage conditions are improved, soon work in with the rest of the soil. Owing to the fineness of this soil, it has a tendency to retain moisture, and when saturated with water, is

slow in giving it up. Upon drying out it contracts considerably, causing the soil to check and crack into small blocks somewhat cubical in form. In the management of this soil, due care must be taken not to plow or cultivate it when in a wet condition. It will invariably bake and form large clods that are not easily broken up. Fall plowing for this reason is preferable to plowing in the spring.

Frequently "white clay" spots are found. These have a tendency to run together when wet, and become heavily encrusted when dry. This condition may be remedied by incorporating more vegetable matter in the soil.

The Superior clay, on account of its high content of fine earth, (about 75 per cent of the soil mass consists of clay and silt, which are the two finest divisions of earth particles) is liable to erode badly, especially if the slope is sufficient to cause water to move rapidly over it. See Plate X. At first only small V-shaped water courses are formed, tributary to some river or stream, which carries water during the entire year. The small water courses, which are active only during spring freshets, or after heavy rains, soon become deeper and wider with other tributaries leading to them. These V-shaped ravines vary in depth from a few feet at the head of stream beds, to 50 or even 100 feet near the outlet. As a result, in some sections the land is cut up badly, making a convenient arrangement of fields on a farm often times impossible. The interstream areas are broad, plainlike, with gradual slope toward Lake Superior. (See Plate XI.)

The area of Superior clay included in the belt beginning in the vicinity of Port Wing, and extending around the Peninsula almost to the Ashland County line, has been modified to some extent by the movement of the ice over it. The clay on the Apostle Islands has also been modified in this manner. The soil within this area lacks uniformity, and is less tenacious, as a rule, than the clay found elsewhere. A thin covering of sandy or silty material is frequently found overlying it. Generally the deep gullies are of less frequent occurrence. The surface features are rolling with some level areas; stoniness is common, though not sufficient to interfere with agricultural operations.

The following table gives the results of the mechanical an-

VIEW SHOWING THE UNEVEN SURFACE FEATURES OF SUPERIOR CLAY.

difficulty where they occur in the laying out of fields con-

VIEW SHOWING THE LEVEL CHARACTER OF SUPERIOR CLAY NEAR SUPERIOR.

alyses of a typical sample of this soil, and also of a sample that has been modified by ice action.

TABLE 9.—*Mechanical Analyses of Superior Clay.*

Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Typical Superior Clay:							
Soil	.3	1.8	2.0	6.4	7.3	38.8	43.4
Subsoil	.1	1.5	2.9	8.0	5.4	36.9	45.2
Modified Superior Clay:							
Soil	.6	2.8	4.7	11.6	12.6	31.3	36.4
Subsoil	.9	3.9	6.0	13.9	14.2	29.8	31.3

Native Vegetation. This soil formation produced a heavy growth of white pine, Norway pine, hemlock, and mixed hardwoods mainly yellow birch. In the western section of the area, little if any hemlock developed. The pine has practically all been removed. The second growth now developing is largely composed of aspen, poplar, white birch, and balsam.

Agriculture. This is one of the most important soil types in the area. Agriculturally the soil is productive and yields profitably under proper management. Development, however, has been retarded, due in part to clearing, which is always slow in a heavily wooded country. Again, large tracts were kept off the market until recently by mill owners, until the timber had all been cut.

With improved and cheaper methods of clearing land by use of power pulling machines, cheaper form of explosives, and more intelligent care in their use, this area will see a rapid expansion in the development of fine farms. The cost of clearing varies, depending on the character and number of stumps per acre, and length of time since the timber was cut. When the work is done by hired help, the cost ranges from $25.00 to $40.00 per acre, including the cost of dynamite and plowing. Invariably the new settler clears and develops his land as his time and means permit. Grass seed and clover sown among the stumps affords excellent pasturage, as well as hay for his use. The stumps are then gradually removed, and the cost of clear-

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ing much lessened. Cut-over lands in an undeveloped state can be bought for $10.00 to $25.00 per acre. Similar soil in old farm sections of the state is valued at $100.00 per acre and over.

While a limited amount of good water may be obtained in shallow wells, it is insufficient for general farm supply. It has been the experience of farmers, that to get a sufficient flow, deep wells are required. From a large number of wells investigated, the average was found to be between 100 to 200 feet, entailing considerable expense in drilling.

The area is well fitted for diversified farming. Dairying has been found a profitable means of converting crops grown on the farm into cash. Clover and grasses are crops, the yields of which cannot be surpassed. Alfalfa has proved successful on well drained land. The soil being of a limey nature supplies one of the conditions essential for its growth. The splendid adaptability of the soil has led many to follow hay farming exclusively. Weed infested fields are a natural result. Growing alsike clover for seed has been found profitable business. It produces good crops of forage, besides yielding 4 to 6 bushel of seed per acre. Alsike is invariably a sure crop. Small grain, especially wheat, have given excellent yields. Root crops —rutabagas, turnips, cabbage, and potatoes—are dependable crops, as a rule. Turnips and rutabagas afford valuable succulent feed and may be used to supplement corn silage. Corn does not always reach maturity, except for ensilage purposes. The Flint varieties have been found best adapted to this section. Field peas are profitable crops and should be more generally grown. Yields of 35 to 40 bushels per acre have been obtained on this soil at the Ashland Branch Experiment Station, under ordinary methods of tillage and fertilization.

Management of Clay Soil. In the proper management of this soil, due regard must be had, (1) to insure proper drainage conditions, (2) to improve the physical condition of the soil, and (3) to increase the supply of phosphorus, which repeated chemical analyses has shown to be below normal.

Poor drainage is the limiting factor in crop production over large areas. Plowing in narrow lands, and connecting up the dead furrows about 3 to 5 rods apart with an outlet ditch, is one of the cheapest, as well as one of the most efficient means of removing surplus storm waters. Due to the

compactness of this soil, the water is absorbed very slowly, so that the need of removing surface water quickly, is apparent. The soil, however, when once saturated is slow in giving up its moisture, if dependent upon evaporation alone. Consequently the soil is slow in warming up in the spring, and growth is retarded accordingly. Tile drainage has been found effective in removing surplus water, even though the soil is very clayey and compact. It has been found that this type of soil is given to checking and cracking upon drying out, causing seams and cracks to form which serve as water ways toward the tile, and, by continued use, become fixed. In some instances, surface ditches may suffice; while in others, tiling supplemented by surface ditches are essential in order to insure maximum crops.

The physical condition of the soil may be improved by thorough cultivation, including plowing, and the incorporation of organic matter—crop residues, green crops, and barn yard manure. Plowing should always be done when the land is sufficiently dry, so as to avoid puddling. The first plowing should not exceed 4 to 5 inches, in order not to turn under too deeply the vegetable mold with which bacteria and other organisms are associated. Ultimately the plowing should be deepened, the work to be done gradually, however, until a depth of 7 to 8 inches is reached. Not only should this soil type be plowed deeper, but it should also be plowed oftener. In too many instances the land has been left in old hay meadows, which become weed infested and difficult to get in good tilth when it is again plowed.

The organic matter content in ths soil in the original state is relatively small, and when it is understood that soil nitrogen is combined with the organic matter, the importance of increasing the supply of this material in the soil can be fully appreciated. Turning under an occasional clover crop or other legume is the ideal way of adding organic matter, since legumes have the ability to utilize atmospheric nitrogen, and possess this advantage over other green manuring crops. The incorporation of more organic matter also intends to improve the tilth of this soil, making it more mellow and more easily worked.

From a considerable number of chemical analyses it was found that the phosphorus content to a depth of 8 inches over an acre was about 900 pounds. This is scarcely sufficient to grow 100

twenty five-bushel wheat crops. In order to maintain good yields the supply of this element should not only be maintained, but increased, if possible. Plot tests using phosphatic fertilizers have, in every instance, borne out the results of chemical analyses, by producing bigger and better crops. At the Ashland Branch Station where these fertilizer tests have been conducted for several years the following data were obtained:

	10 ton manure only.	10 ton manure and 1000 lbs. rock phosphate.	Per cent of increase.
Potatoes	87 bu. per acre	128 bu.	47%
Rutabagas	108 " " "	137 "	27%
Corn	30.4" " "	36.8 bu.	21%
Clover Hay	2,223 pounds.	3,177 pounds	43%
Clover Seed	217.5 "	336.7 "	47%

These results leave no doubt as to the benefit of supplementing manure with rock phosphate.

For further discussion as to the management of clay soils, the reader is referred to Bulletin 202, a copy of which can be obtained by addressing the College of Agriculture, Madison, Wis.

CHAPTER VI.

PEAT.

Peat represents an accummulation of vegetable matter composed chiefly of roots and tops of grasses, sedges, moss, leaves, and other decaying organic matter in various stages of decomposition. Sometimes small amounts of earthy material are incorporated in it. The term muck is often applied incorrectly to the same material. Muck, however, contains much clay and silt; is usually darker in color, and the smaller content of organic matter is in a more advanced stage of decomposition than that of peat.

The one condition which is largely responsible for the formation of peat is poor drainage. Such a condition may be brought about in various ways. In this section of the state, the movement of the ice over the country has been an important agent in causing the formation of peat bogs; either by blocking established drainage channels, or in forming depressions containing water a part of the year. The plant growth developed in these sags on account of excessive moisture and lack of air, soon accummulated and formed a peat bog. Old abandoned stream channels often afford suitable conditions for such accummulations of plant residues. The process of peat formation may often be observed along the shores of some lakes where a border of swamp vegetation fringes the shore and gradually keeps encroaching until the entire surface is matted over with decaying matter.

Considerable variation exists as to the quality of peat, depth, color, and stage of decomposition. It is generally fairly well decomposed, and when wet, dark brown to black in color. The depth is variable; in many cases ranging from less than a foot on the edge of the marsh to many feet near the center. The subsoil beneath the peat depends to a large extent upon the adjacent upland, and as a rule, is similar to it. Invariably this

material is acid. Included within the area mapped as peat, there are conditions of drainage, and of native vegetation that may be best described separately. In a broad, general way, three types may be noted.

1. Areas spoken of as open marshes, and upon which timber developed only in small isolated tracts or islands of upland. The best expression of this type is found in towns West Marshland, and Anderson in Burnett County. In each of these areas there are vast tracts of a prairie-like country, studded here and there by small clumps of Jack Pine, which developed on the upland soils within the main body of the marsh. These isolated wooded areas range in size from a few square rods to several acres, and cannot be shown on a small scale map. The vegetation consists principally of wire grass, the production of which has given rise to the important industry in fiber mat and carpet manufacturing.

The development of this industry in Burnett County has been rapid, so that at the present time practically all available ground suitable for wire grass is taken up by several textile manufacturing companies. Considerable money is expended in building roads and constructing ditches and otherwise improving the marshes so that best results are obtainable. Peat land that was considered at first only of nominal value has been sold upward of $30.00 per acre, and now devoted to growing wire grass. Yields range from 1 to 1.5 tons per acre. The peat is well decomposed, of rather dark color, and quite uniform in character. The subsoil is usually sandy. From a limited number of analyses this peat appears to contain higher percentage of essential plant food constituents than many of the peats in the state.

2. The next type embraces 75 per cent or more of the entire peat area, and is frequently spoken of as swamp land. This group differs from the preceding in that as a rule it is heavily timbered, or was so at one time, and now is cut over or burnt over land. The timber growth varies markedly both as to species developed, and the stand. While often it is difficult to classify areas on account of intermingling of species, yet areas in which tamarack is the predominant tree growth occur; in others, cedar, or black spruce, or the black ash. As a result such terms as tamarack swamp have arisen, meaning that tamarack is the pre-

dominant tree growth. The stand of timber has been remarkably dense in places. This is especially true of some areas in Douglas and Ashland counties. The soil is generally well decomposed peat, and varies considerably in depth. Very often it carries considerable earthy material washed in from adjacent upland.

3. The last type is one which is separated on the basis of drainage. This area includes tracts, some of which are quite extensive, as the one north of Odanah in Ashland county, bordering along the shore of Lake Superior. These areas for the most part are subject to overflow, and are usually classed as swamps in the true sense. Generally there is only a relatively small difference between the level of the water and the surface of the swamp, so that only by expensive methods of drainage could these tracts be reclaimed. In some cases, sand bars or series of bars are thrown along the outer edge of the marsh. In most cases, these low areas lie along meandering streams which flow through them. Agriculturally, these are of little value, except in local areas. Portions were heavily wooded where conditions favored tree growth.

Management of Peat Soil. The first step in the development of a peat marsh is drainage. In the case of a large marsh, a drainage district may be organized by the several owners, and the work done more cheaply that way. Small areas may be drained by open ditches, or by drain tile where the fall is sufficient for an outlet.

The marsh when once drained should be plowed, preferably in the summer or early fall months. Compacting the soil by the use of a heavy roller firms the soil, greatly improving the seed bed for crops. Rolling also hastens the chemical decomposition of the peat, thus liberating plant food. Chemically, peat soil differs from upland soil in that it has a very large amount of nitrogen, due to the high content of organic matter, and, relatively, a much smaller amount of the other essential plant food elements,—phosphorus and potassium. This difference is brought out clearly in the table giving the average composition of upland loam soils and marsh soils expressed as per cent and as pounds per acre eight inches.

	Per cent.			Pounds Per Acre 8--inches.		
	Potassium.	Phosphorus.	Nitrogen	Potassium.	Phosphorus.	Nitrogen
Peat	.50	.098	2.30	1,750	343	8,050
Upland loam	1.90	.070	.12	38,000	1,400	2,400

The high nitrogen and the low phosphorus, and potassium content, is at once apparent, and furnishes some information with reference to the fertilizer treatment of peat land. In general, it may be said that it is poor economy to apply fertilizer of any description which contains nitrogen, such as stable manure or mixed fertilizers. Barnyard manure should, therefore, be applied to the upland soils, and only such commercial fertilizers purchased as are really needed. This will usually include phosphorus and potassium, and may be supplied in the form of rock phosphate and sulphate of potash. Wood ashes also contain considerable amounts (4 to 5 per cent) of potassium. The peat marshes in northern Wisconsin are invariably acid, indeed so strongly acid that it is not practicable to neutralize the acidity. Nor is it necessary to correct the acid condition for the crops usually grown on peat soil. The crops which may be grown are limited by the length of the growing season, and injurious frost conditions which prevail in some places, especially in areas of insufficient air drainage. Splendid yields of timothy and alsike hay are obtained from marshes where the peat has been properly pulverized. A hay meadow should not be permitted to lie too long, but plowed up, and a grain or cultivated crop removed before reseeding. Oats and barley are good grain crops, and return good yields. Cabbage, turnips, and potatoes may also be grown.

The result of fertilizer treatment on yields of hay are interesting, and indicate the possibilities of this soil type when properly fertilized.

TABLE 10.—*Yields and Treatment of Peat Soils at Phillips, Price County, Wisconsin.*

Plot.	Treatment, pounds per acre.	Hay per acre.
		Pounds.
O	Sulphate of potash, 100	4.588
P	Acid phosphate, 275	5.015
Q	Sulphate of potash, 100; acid phosphate, 275	4,848
R	Blank	2,727
S	Sulphate of potash, 100; acid phosphate, 275	4.906
T	Sulphate of potash, 100	4,781
U	Acid phosphate, 275	5,158
V	Manure, 15 loads	2.476

MARL.

Very frequently deposits of marl are associated with peat beds. This whitish sticky material represents an accummulation of shells of fresh water molluscs, and indicates that the bog was formed from the choking up of a lake by the accummulation of vegetable matter. Marl, in the dry condition, is a very fine powdery material and composed principally of lime carbonate. It is mentioned in this connection on account of its value as a neutralizer of acidity in soils. For this purpose it is equal in value to ground limestone. The deposits found were usually of small extent, and considerable distance from shipping facilities. They are, however, valuable locally to farmers within reasonable hauling distance. It should be spaded out and allowed to dry, when large quantities can be hauled. One to two tons is an average application, depending somewhat on the degree of acidity. Marl deposits were found in Section 36, Township 37, Range 19 West; Section 5, Township 44, Range 9 West, along the Clam River in Section 16, Township 38, Range 15 West, near the Yellow River in Section 2, Township 38, Range 13 West. Along the Trade River in Sections 26 and 27, Township 37, Range 18, a tract 20 acres or more in extent occurs. Unquestionably many similar deposits occur elsewhere in the area under discussion.

CHAPTER VII.

MISCELLANEOUS.

Meadow.

Meadow comprises land lying along river bottoms, and represents areas once submerged, but owing to readjustment of drainage conditions, have been left as dry land adjacent to present stream beds. Practically the entire type occurs along the Brule and the St. Croix River channel. In early geological periods, this channel was occupied by a single stream which embraced the entire width of the present bottom lands, and whose course was in the direction of the present St. Croix.

The width of the bottoms varies from a few rods to a mile or more in the vicinity of the St. Croix flowage in Douglas county. The soil is difficult to classify, and varies from deep deposits of peat to sandy loams and even clay loams. Extensive areas of peat have been shown on the map wherever they occur. The sandy or sandy loam types of soil predominates, but lack uniformity over any considerable area. In the vicinity of Gordon, heavy red clay out-crops near the surface in places, or occurs as subsoil. Stoniness is very common, and in local areas, the stone cover the ground almost completely. Frequently, patches occur in which a heavy accumulation of moss and vegetable matter over-lie the harder soil beneath.

Nearly all the meadow land was forested; the growth in some places being very heavy and consisting of cedar, spruce, elm, and jack pine. Agriculturally, it has little value, except locally where a number of farms have been developed. Good pasturage and hay may be secured from some of it.

BEACH SAND.

This formation is of limited extent and is found only in places where the combined action of the wind and waves makes its deposition possible. Along the border of the Apostle Islands it is usually found in small, isolated, sheltered areas along the south or west sides. Along the mainland, several long narrow areas occur, some of which are of considerable economic importance. The Duluth-Superior harbor is protected by Minnesota Point—a narrow body of beach sand which has been deposited by the St. Louis River, at its mouth, and piled up to a considerable height by the action of waves and wind. Long Island, formerly a point off the mainland of Ashland County, was also formed in a similar manner.

The material is usually a light colored fine to medium sand with no apparent difference in soil and subsoil. It supports scant vegetation of sand cherries, wild vetch, and some blueberries. On some of the older and larger tracts, a growth of small pine has developed.

ROCK OUTCROP.

Rock outcrop includes areas where the underlying rock of the region is exposed, or comes very near the surface. These areas occur principally in Ashland, Douglas, and Bayfield Counties. They are indicated by means of a symbol wherever the outcrop occurs within any particular soil type.

CHAPER VIII.

CLIMATE.

The agricultural possibilities of any section are profoundly influenced by its climatic conditions. For certain lines of agriculture, the climate may be of even more importance than the soil. The fruit industry is a localized business, the success of which is largely dependent upon its location with reference to freedom from late frost, a cool ripening period, and absence of extreme winter temperature. Likewise, the maturing of certain crops as corn, for example, requires a growing season 100 to 130 days in length. Again, the amount and distribution of rainfall is an important factor in limiting the crops which may be grown profitably.

The climate of a portion of this section is modified considerably by its nearness to Lake Superior. The influence of this large body of water is very pronounced along a narrow belt bordering the shore, and extends a considerable distance inland, where the topography does not interfere with the free passage of the winds. The Lake influence is especially marked in cases where valleys, occupied by streams tributary to the Lake, extend many miles inland, and permit of free circulation of air, modified by the presence of this extensive body of water. From a strip along the shore where the effect is greatest, the influence of the Lake becomes of less importance as we proceed into the interior, disappearing at a distance of about 20 to 25 miles.

Besides the Lake influence, the greater part of the six counties, included in the area are subject to the general atmospheric disturbances known as cyclonic storms. These disturbances have their origin in areas where the barometric pressure is low, toward which winds blow from all directions. These areas of low pressure have also a forward movement which affects the direction of wind in its path. The rate at which these storm areas move varies considerably, and usually requires 3 to 6 days

for their passage across the continent. In the United States these storm centers or ''lows'', as they are designated on weather maps, usually originate in the west or northwestern part of the country, and move across the country, leaving the United States in the neighborhood of the St. Lawrence Valley along the Canadian border.

In connection with the climate of any locality, we are concerned chiefly with the amount and distribution of rainfall, and the general temperature conditions which prevail. Throughout the area under consideration, there are at present, nine stations from which weather reports are obtained, for the United States Weather Bureau. Some of these have been in existence only a comparatively short time, while in others, the records are incomplete or badly broken, thus lessening their value very much. Four of the stations have records for only a short period of 3 to 6 years; while others have been in existence over 20 years. The stations at present, together with the length of record of each are:—Ashland 24 years, Bayfield 6 years, Cornucopia 3 years, Grantsburg 24 years, Hayward 24 years, Iron River 6 years, Solon Springs 9 years, Spooner 21 years, and Superior 6 years.

Temperature. In preparing the maps* on temperature for the different seasons for the northwestern section of the state, data from the following stations were used—Superior, Solon Springs, Spooner, Grantsburg, Ashland, Iron River, Hayward, and Bayfield. By examining the maps it will be noticed that the lines of equal temperature, or isothermal lines do not run east and west across the area, but follow a general northeast to southwest, or northwest to southeast course; especially is this the case in summer and in winter. The modifying factors in this connection are, (a) the presence of a large body of water to the north, (b) the topographic features,—high, plateau-like uplands ranging from 500 to 1200 feet above the clay plains which are 10 to 15 miles in width and border the lake shore; (c) the soil conditions, (d) and the influence of the Mississippi Valley which is of minor importance, and only affects the extreme western part of the area under consideration.

The influence of these various factors is quite strikingly illustrated in the mean summer and winter temperatures of the

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*From Bulletin No. 223 Climate of Wisconsin, a copy of which may be secured from Agricultural Experiment Station, Malison, Wis.

area, figures 3 and 4. This is especially noticeable in the case of the mean summer temperature in a strip along the shore of Lake Superior, where the mean temperature ranges from 60 to 65 degrees, while the greater part of the area directly to the south has only a range of 1 to 2 degrees, and is included within

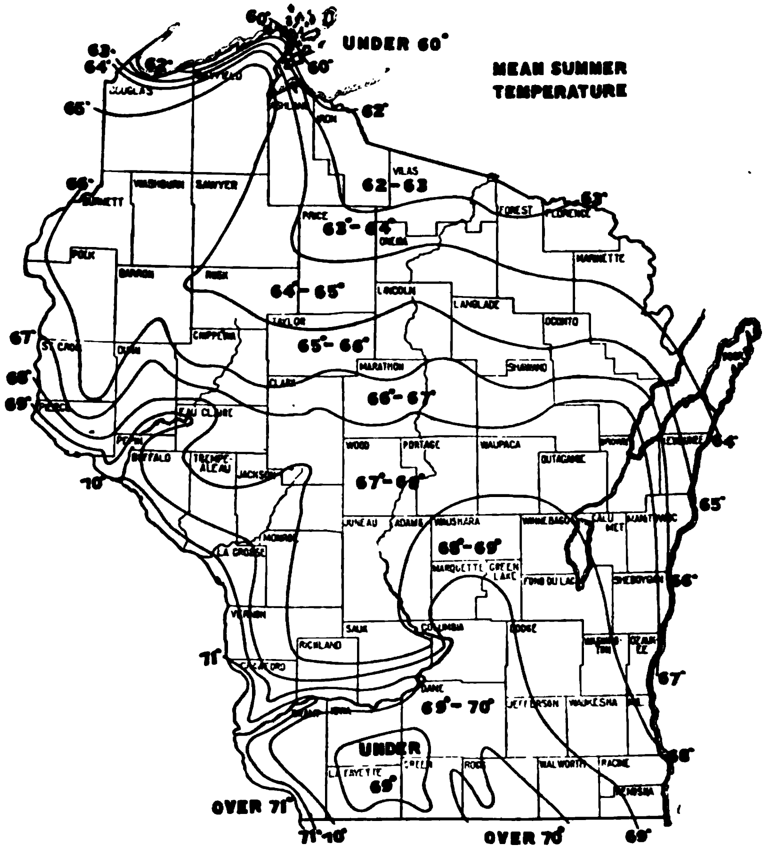

FIGURE 3. COMPARATIVE MEAN SUMMER TEMPERATURE

Average of the daily maxima and minima for June, July, and August.

the zone of 65 to 66 degrees. This is similar to the north central part of the state; the isotherm of 65 degrees, it will be noticed, passes through northern Taylor and Lincoln counties, and then veers off east and southeast through the central part of Kewaunee County.

The mean winter temperature of the Lake border is likewise

modified by its proximity to the Lake; the temperature range for a narrow strip along the shore being 13 to 17 degrees above zero, while the larger part of the six counties has a mean temperature of 12 to 13 degrees above zero.

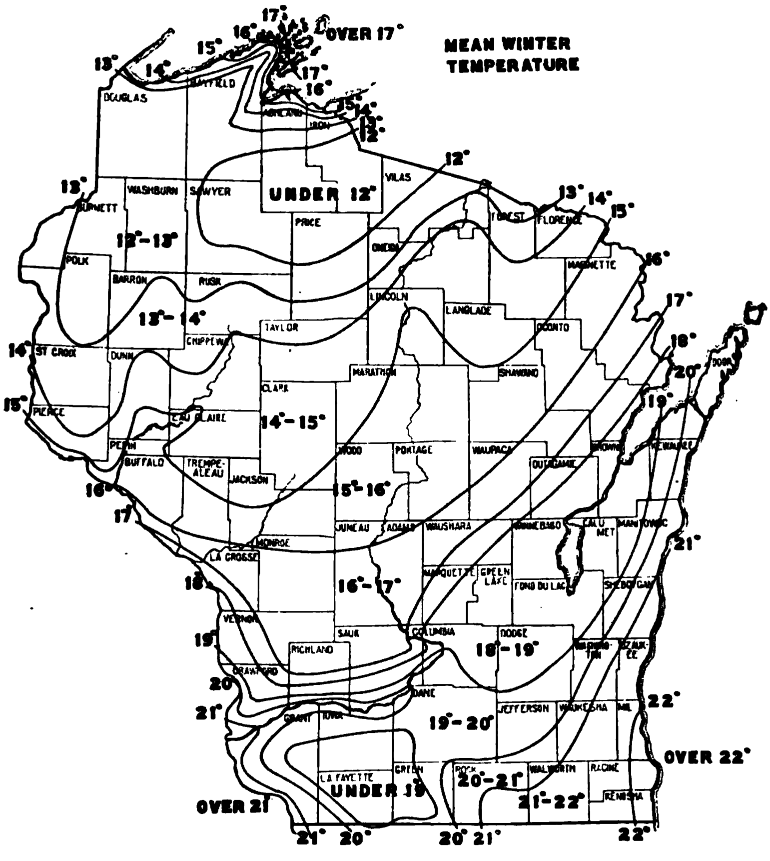

FIGURE 4. COMPARATIVE MEAN WINTER TEMPERATURE

Average of the daily maxima and minima for December, January, and February.

The mean spring and fall temperature, figures 5 and 6, show more uniformity and regularity in the zones. The spring temperatures are lower along the shore, and the season is retarded accordingly. This condition is especially desirable for fruit growing since the fruit buds are retarded until danger of spring frosts has passed. In the fall the land loses heat more rapidly than the water, and consequently the mean

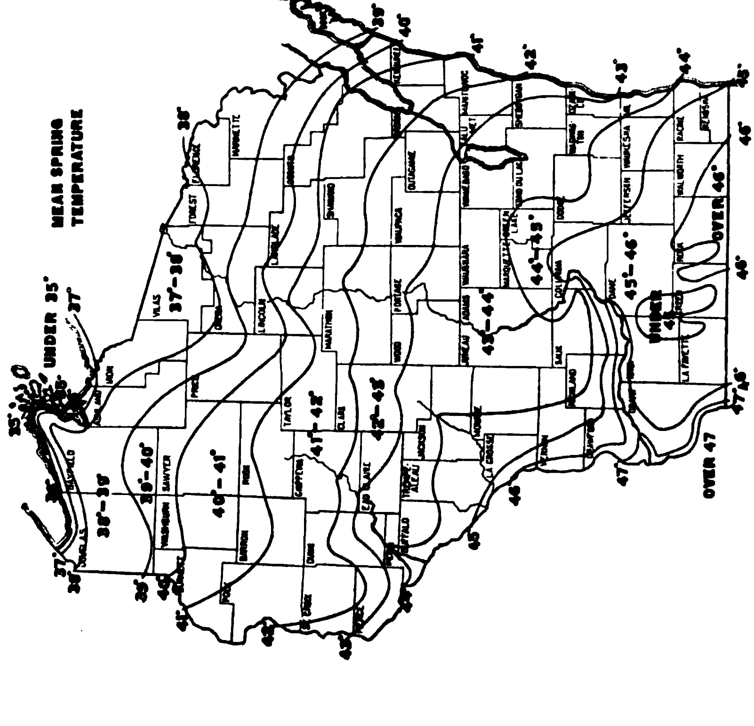

FIGURE 5. COMPARATIVE MEAN SPRING TEMPERATURE
Average of the daily maxima and minima for March, April, and May.

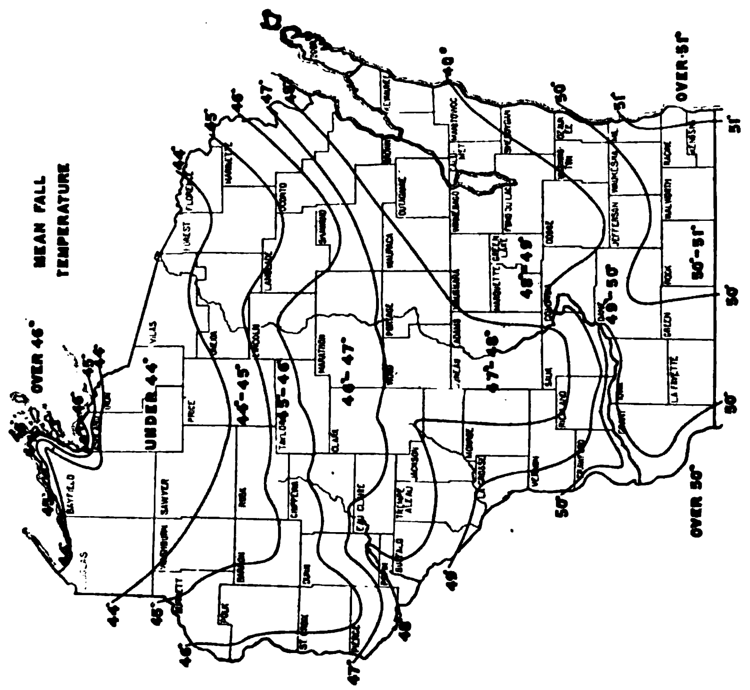

FIGURE 6. COMPARATIVE MEAN FALL TEMPERATURE
Average of the daily maxima and minima for September, October, and November.

temperature is lower inland than near the Lake shore. The mean fall temperature of the interior ranges from 44 to 46, while farther north and along the shore the range is about the same.

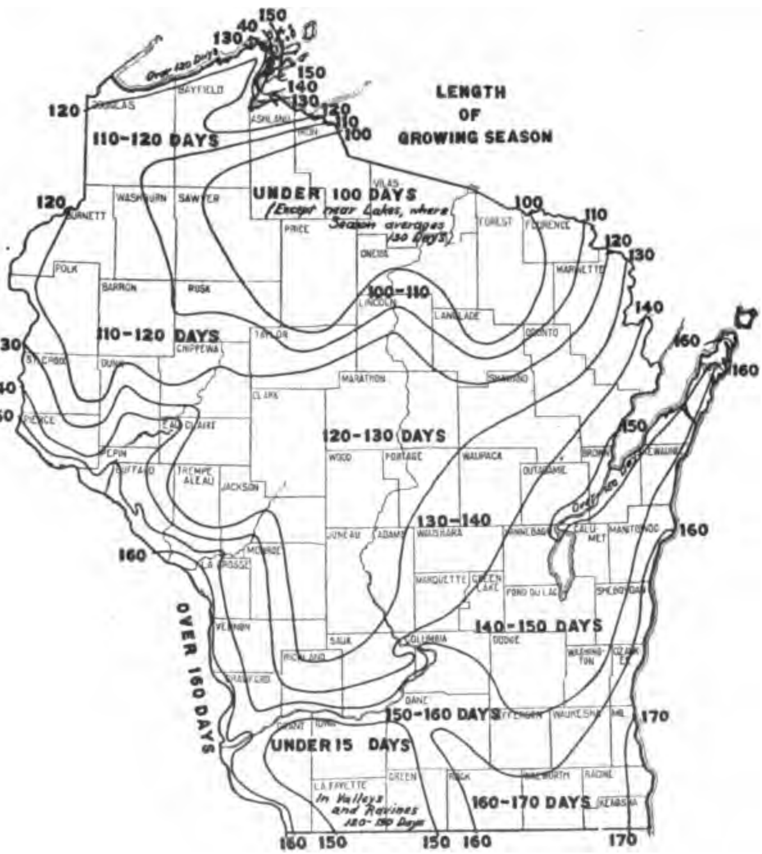

FIGURE 7. COMPARATIVE LENGTH OF GROWING SEASON

This map shows the average number of days between the last killing frost in the spring and the first in the fall for twelve years, 1899 to 1910.

This section of the state has a considerable range of temperature. As a rule, there are a number of days each summer in the interior when the temperature exceeds 100 degrees; the highest thus recorded being 105 degrees. The mean winter temperature is about 12 degrees in the interior. Extremes of 20 or more degrees below zero are frequently experienced. The lowest tem-

perature thus far recorded is 50 degrees below zero. Similar extremes are recorded in the southern and central parts of the state.

Length of Growing Season. In connection with the climate and its influence on agriculture, the length of the growing season deserves consideration. By the length of the growing season, is understood the average number of days between the

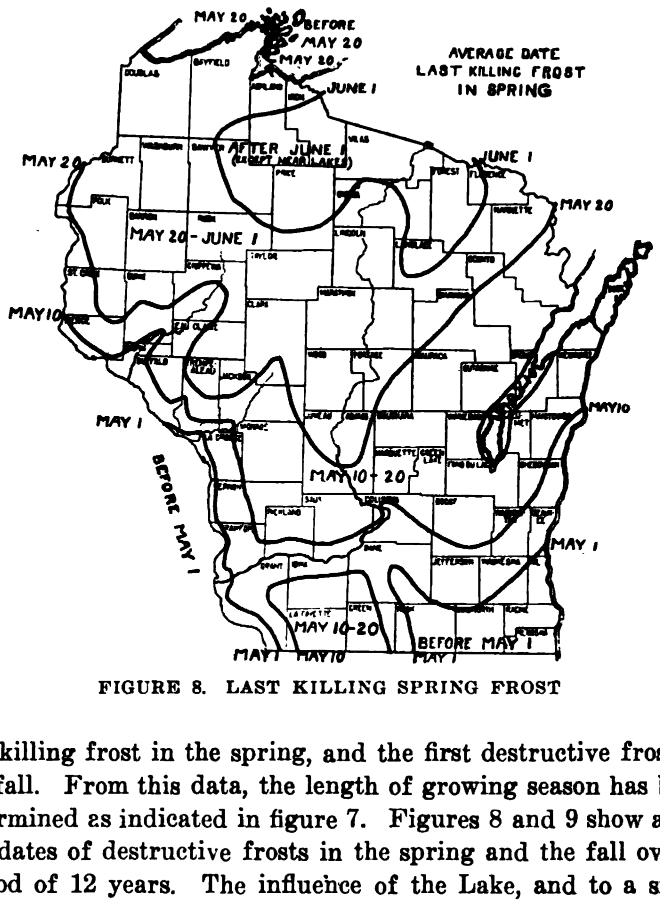

FIGURE 8. LAST KILLING SPRING FROST

last killing frost in the spring, and the first destructive frost in the fall. From this data, the length of growing season has been determined as indicated in figure 7. Figures 8 and 9 show average dates of destructive frosts in the spring and the fall over a period of 12 years. The influence of the Lake, and to a small extent the Mississippi Valley, is quite noticeable. The range from 100 to 130 and 140 days within a short distance is also especially striking.

Effective Heat. In order, however, to interpret intelligently the map showing the length of the growing season, it should be studied in connection with the map on comparative effective

heat, figure 10. A word of explanation may be necessary as to the meaning of the term "effective heat." Plants and vegetables, as a rule, do not germinate or show noticeable growth until a temperature of several degrees above the freezing point is reached. In this discussion 42 degrees was arbitrarily selected as the starting point from which to estimate the amount of heat available for crops. Figure 10 shows by zones the com-

FIGURE 9. FIRST KILLING FALL FROST

These maps have been prepared from the original monthly reports of the observers of the U. S. Weather Bureau for twelve years, 1899 to 1910, supplemented by private records loaned to the authors.

parative amount of heat available for crops from April to September inclusive, and was prepared by deducting 42 degrees from the mean temperature of each station during the 6 months, April to September. In comparing the maps, figures 8 and 9, it is observed at once that while the length of the growing season along the Lake shore of the northern counties may exceed the length of the growing season of the inland regions by 10 to 30 days, yet this advantage is offset to a large extent by the difference in effective heat in the respective areas. This fact is

also borne out by actual experience, where it is found possible to mature corn in the areas with the shorter growing season more often than in regions having a longer growing season. In part this is due to a difference in the soil; one being sandy loam, and the other being clay. The influence of the large body of

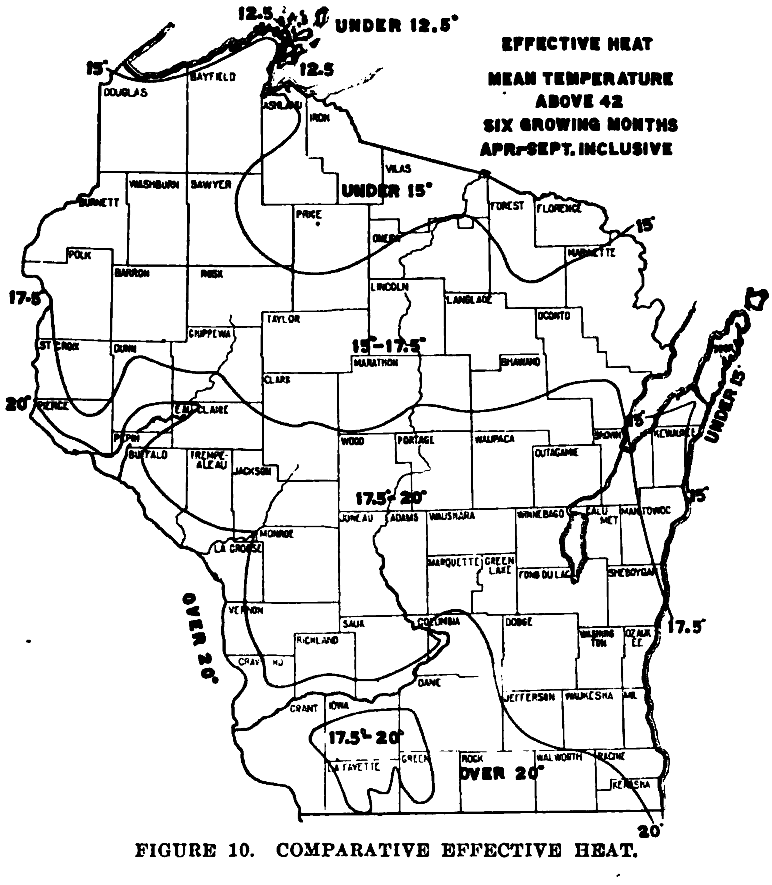

FIGURE 10. COMPARATIVE EFFECTIVE HEAT.

water is, however, of greater importance and tends to prevent extreme temperature conditions, and maintain a more nearly equable temperature throughout the entire year. The growing season is, therefore, cooler near the Lake than in the interior regions not affected by this influence.

Practically the entire area is included in the zone having 15 to 17½ degrees effective heat, and in this respect is as favorably situated as a large portion of Central Wisconsin. "The lower

Mississippi Valley receives the greatest amount of effective heat, the mean temperature at Dubuque and Prairie Du Chien during this period being about 22 degrees above this temperature of 42 degrees. Taking this lower Mississippi Valley as a standard it will be noted that the northern highlands receive one-third less effective heat, while the Michigan shore, and northwestern Wisconsin average about one-fourth less heat; Kenosha County receiving about as much as Buffalo County, Sheboygan as much as St. Croix, while Barron and Washburn Counties during these months are as warm as Manitowoc or Kewaunee, Marathon, or Taylor Counties.''

In this connection it is also interesting to note that owing to its northern latitude, this section of Wisconsin receives more sunlight during the growing season than the southern part of the State. During the summer season, this may amount to one-half to three fourths hours daily.

Wind Direction. Along the Lake shore and extending into the interior for some distance the winds are influenced to a large extent by the Lake. For about six months, April to September, this section is in the path of steady north easterly winds which blow sometimes with marked severity, and are frequently accompanied by cold, wet weather. In the winter, the conditions are changed, and the prevailing winds are southwest. The interior sections are in the path of southwest winds during the spring and summer months, while in the winter more variable conditions obtain, and winds from the south, southwest and northwest occur.

Rainfall. The total amount of rainfall as well as the distribution throughout the growing season is of great importance agriculturally. The following table shows the average monthly rainfall, and also the annual amount for each of the stations for the entire period of record to 1913.

TABLE 11.—*Average Monthly Precipitation for the Growing and Non-Growing Season for the Entire Period of Record of Each Station to 1913.*

	Ashland.	Bayfield.	Iron River.	Superior.	Solon Springs.	Hayward.	Spooner.	Grantsburg.
April	2.00	1.62	2.18	1.69	1.79	1.90	1.78	2.57
May	3.48	4.35	4.17	4.20	3.59	3.59	3.52	4.10
June	3.17	3.36	2.59	1.69	2.55	3.81	3.40	2.41
July	4.14	3.57	5.32	5.66	5.23	3.77	3.94	4.54
August	3.04	3.05	2.87	3.00	3.21	3.41	3.39	3.50
September	3.15	4.57	3.44	3.44	2.62	3.29	3.14	3.94
Mean for the growing season	18.98	20.52	20.57	19.68	18.99	19.77	19.17	21.06
January	1.07	1.59	.90	.45	.83	1.02	.85	1.08
February	1.15	.60	.91	.40	1.22	1.06	.89	1.08
March	1.44	.82	1.41	.81	.73	1.62	1.72	1.60
October	2.70	2.54	2.57	1.91	1.90	3.11	2.79	2.56
November	1.48	1.64	1.84	1.07	1.39	1.42	1.33	1.36
December	1.22	1.49	2.13	1.05	1.19	1.12	.88	1.28
Mean for the non-growing season	9.06	8.68	9.76	5.69	7.26	9.35	8.46	8.96
Mean annual	28.04	29.20	30.33	25.37	26.25	29.12	27.63	30.02

Since the amount of rainfall during the growing season is of much more value to crops, the table has been prepared showing the total precipitation during six months of the year, April to September, or the growing season and a like period from October to March, or the non-growing season. By referring to the table it is found that practically two thirds of the total annual rainfall occurs during the growing season when it exerts most influence on crops. The heaviest rainfall occurs generally in July. In 1910, Ashland and Superior recorded the least rainfall since the establishment of the station, the former indicating 17.59, and the latter 15.67 inches. The wettest years marked a rainfall of 35.7 at Ashland, and 32.92 at Superior. Grantsburg recorded 47.2 in 1903, and 22.90 in 1893, Hayward 42.00 inches in 1900, and 19.65 inches in 1894, and Spooner 42.86 inches in 1900, and 20.63 inches in 1895.

CHAPTER IX.

AGRICULTURE.

That there are opportunities in this area as well as in other sections of Northern Wisconsin for considerable agricultural expansion has been heralded by the press and by men interested in developing the state. It will, therefore, not be out of place to devote a brief chapter to the resources, crops grown, and other statistical matter that will furnish some information with reference to the agricultural opportunities of this section of the state. One of the leading questions to consider in this connection is the character of the soil, and the amount of unimproved land that is adapted for agricultural purposes. The soil conditions and their adaptibility have been discussed in previous chapters. Data as to the acreage of farm land, not improved, hitherto published, has not been satisfactory in many cases. Much of it has been prepared when the land was not easily accessible, and some times by men whose training was along other lines than agriculture. The result has been that invariably the amount of land adapted for agricultural purposes was underestimated. In some cases, this discrepancy was found to be 50 per cent of the true condition.

It should also be said, however, that there may be considerable variation in the agricultural value of much of the land, the same as in any other section of the state. Yet these areas are agricultural land, and will sooner or later be developed. As a rule, the better quality of land is selected first, and while much of this class remains, the less valuable will not be taken up. The cry heard so generally respecting the higher cost of living tends to make more people seek land for a home, as well as a livelihood. This tendency will have the ultimate effect of settling up land more rapidly—the poorer quality as well as the better. Again the work of experiment stations and agricultural colleges, in advancing better methods of soil management, and

selecting crops adapted to particular soils has done much in assisting the agricultural development on all types of soil.

The following table gives the total land acreage, together with an estimate of the amount of undeveloped land that is adapted for general farming. This estimate is based upon data obtained by the writer and his co-workers in connection with the survey of the soils of this section, and while there may be inaccuracies, it represents approximately the conditions as they exist at present. The total land acreage and the acreage of improved land were taken from the United States Census for 1910.

TABLE 12.—*Condition of Farm Land in Northern Wisconsin.*

COUNTIES.	Total Land Surface (U. S. Census 1910).	AGGREGATE AMOUNT OF AGRICULTURAL LAND.		TOTAL ACREAGE OF AGRICULTURAL LAND.	
		Per cent	Acres.	Improved land.	Unimproved land.
Ashland	692,480 acres	70	484,700	24,300	460,400
Bayfield	961,920 "	65	625,200	21,600	603,600
Burnett	550,400 "	75	412,800	56,600	356,200
Douglas	855,680 "	80	684,500	19,900	664,600
Sawyer	844,800 "	70	591,300	10,400	580,900
Washburn	534,400 "	70	374,000	41,500	332,500
	4,439,680 "	71	3,172,500	174,300	2,998,200

Per cent of Total Agricultural land now improved 5.5.

From this table it will be noticed that about 70 per cent of the entire land area is agricultural land, and that less than 6 per cent of this is now under cultivation. Expressed in terms of acres, it may be stated that less than a quarter million acres are improved out of a total of over three million acres in the area. There is certainly room for more settlers.

That this section of the state is becoming rapidly settled and land brought under cultivation is seen from the following table:

TABLE 13.—*Acres of Improved Land 1910 Compared with 1900—(U. S. Census 1910).*

Counties.	1900.	1910.	Per cent increase 10-year period.
Ashland	13,611 Acres	24,374 Acres.	77 Per cent.
Bayfield	8,022 "	21,661 "	70 " "
Burnett	32,626 "	56,601 "	73 " "
Douglas	5,234 "	19,920 "	280 " "
Sawyer	4,871 "	10,428 "	110 " "
Washburn	13,039 "	41,587 "	210 " "

The per cent increase of improved land has been especially marked in the case of Douglas, Washburn, and Bayfield Counties in the 10-year period. It may be confidently predicted that the next decennial period will see an even greater increase.

Crops. In connection with the development of a new country, it is interesting to note the principal crops grown, the acreage of each and the general trend during the 10-year period 1899 to 1909. In general, oats is the principal grain grown in the area, wheat next, and followed by barley, and rye in the order named. Burnett County, however, produces on the average a larger yield of rye than barley, and more corn than grain. Douglas County also produces more rye than barley. Corn is grown only to a limited extent, especially in the counties bordering the Lake. The census figures, however, are not complete, and a considerable amount of corn cut for silage purposes is not recorded in the census reports.

TABLE 14.—*Acreage and Yield of Principal Crops Grown in 1899 and 1909* (United States Census).

Crops.	Ashland		Bayfield.		Burnett.		Douglas.		Sawyer.*		Washburn.	
	A.	Bu.	A.	Bu.	A.	Bu.	A.	Bu.	A.	Bu.	A.	Bu.
Corn												
1899 ...	44	1,190	50	1,760	2,362	51,780	73	2,490	55	2,520	894	18,790
1909....	32	751	255	6,338	5,494	146,792	519	11,430	166	12,575	2,887	[illegible]
Oats												
1899	1,217	34,490	152	4,740	3,073	99,690	135	3,120	686	22,660	1,260	33,400
1909	2,165	55,769	1,608	44,681	5,109	43,219	839	22,108	1,244	32,529	3,731	91,505
Wheat												
1899....	133	2,450	10	200	2,790	50,580	11	180	53	890	783	12,200
1909	411	5,040	245	3,690	3,951	58,309	159	2,368	103	1,352	1,347	15,621
Barley												
1899....	156	3,580	7	150	122	2,710	12	160	9	240	106	1,890
1909....	419	8,944	132	2,604	558	2,494	97	1,811	84	1,718	413	7,637
Rye												
1899....	744	4,650	25	568	1,228	16,070	13	190	5	150	217	4,350
1909....	66	1,222	60	1,091	822	9,397	212	2,521	143	2,407	391	5,460
Potatoes												
1909	724	94,551	1,461	159,710	2,435	287,735	971	111,103	520	69,961	1,729	201,[illegible]34
Medium Clover & Timothy Hay...... 1909	T. 1,018	T. 13,288	T. 8,760	T. 10,418	T. 1,130	T. 16,503	T. 6,700	T. 7,887	T. 2,365	T. 2,670	T. 8,615	T. 10,841

The most important crop in point of acreage is hay, which is largely a mixture of clover and timothy; only a small amount of clover hay is grown. Burnett County, which has the largest acreage of improved land, ranks first in the production of hay, as well as corn. Burnett County also leads in the number of dairy cattle. Attention has already been called to the fact that many of the hay meadows are allowed to remain in hay too long. Many of these old timothy hay meadows produce meager yields, and become sod bound, and are infested with weeds. The progressive farmer may well turn to red clover as a substitute for part of his hay crop.

Specialized industries are important. Potato culture demands more attention in some sections than anything else. The Nemakagon Valley is developing into a tuber section. Small fruits, and orcharding on a commercial basis, are attracting the

attention of the Lake Shore Counties. On the lighter soil types beans are important cash crops raised. During recent years, cranberry culture has received attention. At present there are three cranberry bogs in operation and another under construction. There are many ideal locations in the area for this industry.

Dairying. The dairy industry is an important one in all of the counties of the area. Burnett ranks first, having in 1910 nearly three fourths as many milch cows as all the other counties taken together. The value of the dairy products in each of the counties exceeds the value of the grain raised.

(TABLE 15. *Dairy Statistics—U. S. Census 1910*).

Counties.	Number of milch cows.	Value of dairy products.
Ashland	2,590	77,621 Dollars
Bayfield	2,385	77,211 "
Burnett	7,634	211,900 "
Douglas	2,085	96,242 "
Sawyer	829	20,694 "
Washburn	3,401	101,598 "

The dairy products sold from the farm are mainly butter and butter fat. Creameries are centrally located, many of which maintain collecting wagons, which are sent around to gather the cream from the farmers. This system of farming is found profitable. It provides good cash returns from crops grown, the fertility of which is returned to the soil in a large measure.

Population. The population of the six counties from 1890 to 1910 is shown in the following table:

TABLE 16.—*Population of Counties.*

Counties	1890	1900	1910
Ashland	20,063	20,176	21,965
Bayfield	7,390	14,392	15,987
Burnett	4,393	7,478	9,026
Douglas	13,468	36,335	47,422
Sawyer	1,977	3,593	6,227
Washburn	2,925	5,521	8,196

The greater portion of the population, while mainly native born, is of foreign extraction, chiefly of Scandinavian descent. In Douglas and Bayfield Counties, numerous settlements of Finlanders have segregated themselves in small farming communities. Similar colonies of Poles, Slavonians, Austrians, and Hollanders have been formed in Bayfield County. The Germans are found in less numbers throughout the entire area. In Ashland and Washburn Counties, a considerable number of Canadian French have established small farming communities.

Markets. This area of six counties is located advantageously with reference to markets. Excellent railroad facilities lead to splendid consuming markets at the head of the Lakes—Superior, Duluth, and the Range country to the north. The Twin Cities, Minneapolis and St. Paul, are also commanding markets within easy reach. Good home markets are also maintained, the more important ones of which are as follows:

TABLE 17.—*Population of Cities.*

(U. S. Census 1910)

Ashland	11,594	Spooner	1,453
Bayfield	2,692	Shell Lake	902
Washburn	3,830	Hayward	2,869
Iron River	1,696	Grantsburg	721
Superior	40,384	Mellen	1,833

During the summer months, packet steamers ply between the Lake ports daily, carrying produce to Superior and Duluth. This is of special importance to the fruit shipper without rail facilities.

In the more settled portions, good wagon roads are maintained. Abundant material is near at hand for road building in many parts of the area.